OECD

How can innovative technologies transform vocational education and training

Insights for Ukraine

Disclaimers

This work is published under the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the Member countries of the OECD.

This document, as well as any data and map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Photo credits: Cover © Platoo Creative Studio/Shutterstock.com

Corrigenda to OECD publications may be found at: https://www.oecd.org/en/publications/support/corrigenda.html.

© OECD 2025

Abstract

This policy paper aims to support the development and advancement of Ukraine's vocational education and training (VET) system by exploring the role of key innovative technologies. The paper presents examples of practices across OECD countries on how technology can help engage learners and employers, train learners in simulated work environments with personalised support, assess VET outcomes in innovative ways and align VET with labour market needs, and efficiently manage information exchange and administrative tasks. This paper provides policy insights for Ukraine, highlighting country examples that employ a strategic approach to technology use in VET, promote private sector investment and partnerships as well as multi-stakeholder collaboration to align technological use with learner and labour market needs. It also provides examples of countries providing VET teachers with support to effectively use digital tools and ensuring the ethical, responsible and secure use of technology and data in VET delivery.

Table of contents

FIGURE

BOXES

Executive summary

One of the most compelling opportunities in education, training and workforce development today is using technologies to empower learners, particularly among vulnerable populations. Various recent OECD analyses highlighted how innovative technologies such as artificial intelligence (AI), robots and immersive technologies like virtual and augmented reality (VR/AR) can transform learning environments, experiences and outcomes. These technologies open doors to new possibilities, including in vocational education and training (VET). This paper looks at the potential of digital technology in VET in Ukraine, providing international examples of policy and practice, and policy insights for Ukraine. The paper is part of a VET project under the OECD's four-year Ukraine Country Programme, supporting VET reforms in collaboration with the Ministry of Education and Science in Ukraine.

Ukraine's VET system is undergoing reforms to achieve a better alignment with local labour market needs. These reforms include decentralisation and the development of dual VET models, while providing additional training opportunities for individuals with special educational needs, including war veterans. As Ukraine modernises its VET system, there is an opportunity to explore how innovative technologies can be integrated. Ukraine's post-war economy will require a modern and responsive VET system to develop skills for recovery, reconstruction and a future-proof economy. This system must be inclusive, providing upskilling and reskilling opportunities for various learners, including displaced persons, veterans and others affected by the war. Moreover, digital technologies offer solutions to the immediate challenges that Ukraine's VET sector is faces today, including infrastructure damage caused by Russia's large-scale invasion, interruptions in VET due to safety concerns and teacher shortages.

How can innovative technologies transform VET?

Innovative technologies are transforming VET around the world by improving engagement, enhancing training and management processes and modernising assessment methods. AI and VR/AR engage learners by providing personalised, immersive and interactive learning experiences tailored to individual needs. These tools simulate real-world scenarios, enabling learners to develop practice-oriented skills safely and cost-effectively. For learners with disabilities or learning difficulties, technologies like speech-to-text, text-to-speech applications and interactive simulations provide alternative ways to engage with content and practice skills. These innovations help create an inclusive environment where all learners can thrive and gain the skills needed to enter the workforce.

The role of technology in VET extends beyond enhancing the learning experience for students. Technology also supports VET providers, employers and the overall system. Technology reduces transaction costs and facilitates effective communication. This facilitates greater collaboration among VET providers, employers and learners, ensuring a more integrated and relevant training experience that bridges the gap between education and the labour market. Moreover, digital platforms and AI-based systems help streamline assessment and qualification processes, making evaluations more efficient and transparent.

The international examples of technology use in VET presented in this paper offer insights into the potential of technology to transform VET systems, and provide inspiration for Ukraine's VET reform efforts.

Key policy messages for leveraging technology to transform Ukraine's VET system

While the integration of technology into VET can transform stakeholder interactions, training delivery, and assessment and management processes, realising these benefits requires a re-engineering of various aspects of VET systems. Technology must serve as a means to the broader goal of building a responsive and inclusive VET system. For Ukraine, the process of technology adoption in VET must align with recovery strategies, addressing both immediate and long-term labour market needs while supporting vulnerable groups. Moreover, responsible, ethical and secure technology use must be central to this transformation.

Significant challenges hinder technology adoption in VET. Many VET providers around the world struggle to keep pace with evolving digital tools due to talent shortages, resource constraints and high implementation costs. Ukraine faces additional hurdles, including war-related infrastructure destruction, displaced educators and learners, and budget constraints.

Given these constraints, investments should prioritise scalable, cost-effective and adaptable solutions, leveraging existing platforms like Ukraine's on line VET training platform Profosvita to expand digital learning opportunities. To ensure accessibility, targeted investments in assistive technologies are needed, particularly for learners with disabilities and veterans. The key policy messages for Ukraine presented in this paper are:

- **Strategic approach, investment and collaboration:** Successful technology integration requires a clear strategy, sustainable investment and stakeholder collaboration. Public policies, private sector engagement and international partnerships are critical for funding and capacity-building in Ukraine.

- **Aligning technology use with VET pedagogy:** Teachers must be equipped with the skills and confidence to integrate technology effectively. Ukraine should expand teacher training initiatives, building on existing tools like Profosvita.

- **Responsible, ethical and secure use of technology and data:** Safeguarding data privacy and ensuring ethical AI implementation in VET are crucial, especially given Ukraine's digital security threats. Transparent standards and clear communication about technological limitations in assessment and certification in VET will foster trust.

By addressing these priorities, Ukraine can use technology as a transformative tool to rebuild and modernise its VET system, ensuring it is inclusive, resilient and aligned with evolving needs. International examples of policies and practices in these areas are presented in this paper. By leveraging lessons from these examples, Ukraine can ensure that its VET reforms are effective and sustainable, ultimately contributing to the nation's broader economic recovery and development goals.

1 Introduction and context

One of the most compelling opportunities in education, training and workforce development today is using technologies to empower learners, in particular among vulnerable populations. Various recent OECD analyses (OECD, 2023[1]; OECD, 2024[2]; OECD, 2023[3]; OECD, 2023[4]; OECD, 2022[5]; OECD, 2021[6]) have highlighted how innovative technologies such as artificial intelligence (AI), robots and immersive technologies (such as virtual and augmented reality) can transform learning environments, experiences and outcomes, and open doors to new possibilities, including in vocational education and training (VET). For countries like Ukraine, where the development of VET is critical, especially for developing the right skills for the post-war economy, these technologies present a strategic path forward. By integrating innovative tools in the design and delivery of VET, Ukraine can develop and advance its VET system, making VET more accessible, personalised, and future-oriented – helping rebuild and strengthen its workforce while fostering inclusion and resilience.

1.1. About this paper: Context and objective

The OECD's four-year Ukraine Country Programme allows Ukraine to leverage OECD expertise and best practices, strengthen institutions, and build capacity for successful reforms that will help Ukraine strengthen institutions, enhance economic resilience and ensure that reconstruction aid is used to the best effect to promote economic development and citizens' welfare. Launched at the OECD's 2023 Ministerial Council Meeting, the Country Programme consists of 22 policy reviews and 9 capacity-building projects, running until 2027. The Programme is financed by OECD and non-OECD donors (OECD, 2023[7]).

Reflecting the priorities of the government of Ukraine, with its focus on laying the foundations for long-term well-being and opportunities for its people, the programme encompasses key reconstruction challenges such as infrastructure policy and support for internally and externally displaced persons, as well as education and skills. One of six policy areas covers human capital, social and cultural development. As part of this policy area, VET was identified as a key priority. In consultation with the Ukrainian Ministry of Education and Science, the OECD work on VET in Ukraine focuses on i) reviewing the range and content of vocational qualifications on offer and providing guidance for an efficient qualification updating process; ii) reviewing the scope and functionalities of the online VET training platform and providing additional training materials; and iii) identifying international good practices of technology use in VET that can inspire Ukraine in its efforts to modernise VET.

This paper **identifies innovative technologies in VET** across OECD countries and **reviews their use and outcomes**, with the goal of **informing Ukraine's efforts to reform its VET system, policies and practices**. It provides examples of technology use cases across OECD countries that may be appliable or of interest for Ukraine. It pays a special attention to the technologies that support learning through personalised, adaptive and tailored approaches. These technologies also include non-VET specific technologies that are or can be adjusted to suit VET needs, and digital solutions that help students develop vocational skills (OECD, 2023[1]).

1.2. Ukrainian context: How can Ukraine's VET system benefit from the use of innovative technology?

The Ukrainian VET system is undergoing important reforms. The Ministry of Education and Science of Ukraine is currently developing a network of senior specialised academic and professional education institutions for the delivery of upper-secondary education, which is being piloted in 2024-25 and to be fully implemented by 2027. Under the reform, students completing 9th grade will transition to reformed specialised upper secondary schools, such as academic lyceums or vocational colleges. Most regions are already preparing for this reorganisation. To better align VET with local labour market needs, the management of VET was decentralised, with a focus on fostering dual VET and additional training opportunities for individuals with special educational needs, including war veterans. For this, the Ukrainian government has allocated UAH 549 million (about EUR 12 million) to transform VET and create 100 workshops as practical learning centres within existing VET institutions. These centres have modern technology and equipment at their disposal, and will promote collaboration with businesses and target high-demand sectors based on regional needs, such as agriculture, repair, clothing design and the culinary sector (Ministry of Education and Science of Ukraine, 2023[8]). As Ukraine moves forward with modernising and reforming its VET system, now is the time to plan ahead and explore innovative technologies that can be integrated into these efforts.

Ukraine's VET sector faces significant challenges, including infrastructure damage from Russia's full-scale invasion, learners who faced interruptions in learning due to safety issues, health problems and (temporary) relocations, and teacher shortages. Digital technologies offer promising solutions to these challenges and indeed have managed to fill some existing gaps so far, especially in the form of online learning. Tools such as virtual and augmented reality (VR/AR) and AI can play a crucial role in bridging gaps, especially in cases with physical, distance and infrastructure limitations (OECD, 2021[6]). With Internet connectivity and certain equipment, these technologies can reach any learner, simulate hands-on learning experiences anywhere and enable VET remotely. The COVID-19 pandemic and recent advancement of technologies have spurred the use of online learning.

Moreover, Ukraine's post-war economy will require a modern and responsive VET system that can develop the skills needed for recovery and reconstruction and for building a future-proof economy and society. Such a modern VET system will need to be inclusive, providing relevant upskilling and reskilling opportunities for various learners, including externally displaced persons who returned to Ukraine with skills and qualifications acquired abroad and/or with skill gaps, and veterans transitioning from military to civilian life through earning relevant skills and qualifications for sustainable employment as well as other learners with various health issues related to the war.

Already in 2023, 77% of VET institutions had students with disabilities (Ministry of Education and Science of Ukraine, 2024[9]). In 2024, the Ministry of Education and Science of Ukraine approved a 'Roadmap for the Development of Vocational and Technical Education for Persons with Disabilities and Low-Mobility Groups through 2030'. The Roadmap recognises the need for ensuring accessibility and reasonable adaptation of buildings for the target groups during the construction and reconstruction of VET institutions as well as organising favourable training conditions for them. For example, measures include special adaptations of computers and computer programmes; multimedia and demonstration equipment; three-dimensional, sound and interactive models; and electronic devices for training people with visual impairments. The deployment of such equipment that enables the use of digital tools and online platforms will play a critical role in ensuring inclusive access to VET. In particular, the use of assistive technologies in learning environments, such as adaptive software and AI-driven tools will be essential to bridge the accessibility gap. Moreover, as the Directorate of Vocational Education will monitor progress towards the Roadmap annually with a reporting requirement, data-driven technologies and analytics could be utilised to track progress, identify challenges, and adjust training approaches. These programmes should address unique challenges veterans face, such as physical disabilities, PTSD, or skills misalignment between

military service and civilian jobs. Technologies in VET presented in Section 2 can build a foundation for such endeavour in Ukraine.

Box 1. Training needs of war veterans in Ukraine

As of 1 July 2022, the number of war veterans in Ukraine was 438 834 (Ukrainian Veterans Fund, 2022[10]) and is expected to number more than five million post-war – i.e. more than 10% of the population (Odarchenko, 2024[11]).

War veterans' access to retraining courses and professional development is crucial for their smooth reintegration into civilian life. Many veterans returning from war face the challenge of changing jobs, fields, or employment status, often uncertain about their next steps. According to a 2023 survey among mobilised individuals, only 31% plan to return to their previous job after demobilisation (Kirillova, Znoviak and Kazan, 2023[12]). 53% of respondents in that survey reported that they need support for retraining. (Kirillova, Znoviak and Kazan, 2023[12]).

The situation is further complicated by the high number of veterans dealing with injuries or disabilities, who may face even greater barriers to their re-integration in the labour market. In 2023, among veterans with the status of Combat Veterans or disabled veterans as a result of the war who are not currently in active service, 58% have faced obstacles to employment after military service (Kirillova, Znoviak and Kazan, 2023[12]).

Ukraine can build upon and take advantage of the recent global advancement in the use of innovative technology in VET, and the country has already launched various initiatives in response (Box 2).

Box 2. Emerging use of technology in VET in Ukraine

Ukraine has driven the digital transformation in education first by establishing the Ministry of Digital Transformation in 2019. Digital Transformation Officers were appointed in 2020 at the Ministry of Education and Science (MoES) and in 2021, the Directorate of Digital Transformation in Education was established within the MoES. Around this time, over 90 projects were launched, including EU initiatives such as the SELFIE – a free, customisable tool to help schools to enhance capacity to use digital technologies in learning. Moreover, the International Labor Organization (ILO), in collaboration with the MoES, developed e-learning solutions for VET institutions focusing on the hospitality, mechanical, electrical, and garment sectors.

An e-learning platform (Profosvita, https://profosvita.online/) was developed in 2022 to make digital learning materials more accessible, e-courses for instructors on e-learning, teacher training, or interactive training modules for students. This free of charge online platform provides VET courses (some corresponding to national curriculum) across 43 categories, covering 161 online courses in agriculture, construction, plumbing and other sectors. Additionally, it provides short training courses and interactive games focused on employability and management skills. This platform can also redesign and incorporate courses from other platforms. Certification upon course completion is available for some courses in this platform. Some courses are for teachers, some are for students. Courses that come from other countries have Ukrainian subtitles, and work is underway to incorporate accessibility features for users with special needs. The OECD is currently supporting the MoES to improve this platform to better serve to the VET community in Ukraine.

In 2024, Mriia, a pilot educational platform, was launched to support young Ukrainians to develop educational and vocational skills. Once rolled out across all educational institutions in Ukraine, the platform will enable direct communication between parents, teachers and students, with end-to-end encryption encoded. It will also provide a comprehensive content library, video and media courses and tests. The Ministry of Digital Transformation and Ministry of Education teams have already started working on implementing the application in out-of-school, preschool, higher education and vocational education.

Source: OECD (2022), "How vocational education and training (VET) systems can support Ukraine: Lessons from past crises", https://doi.org/10.1787/e8e86ce2-en; ILO (2022[13]), Strengthening digital TVET in Ukraine, www.ilo.org/skills/Whatsnew/WCMS_836777/lang--en/index.htm; Ukraine Association (2024[14]), The Ministry of Digital Transformation presented the Super App Mriya to the IT Ukraine Association and regional clusters, https://itukraine.org.ua/en/the-ministry-of-digital-transformation-presented-the-super-app-mriya-to-the-it-ukraine-association-and-regional-clusters/; EBA (2024[15]), Mriia launched, https://eba.com.ua/en/zapustyly-mriyu/.

1.3. The role of innovative technologies in vocational education and training

Technology can be used by VET providers and employers, but also at higher-levels to influence the overall VET system (Amenduni and Cattaneo, 2022[16]). It reduces transaction costs in matching learners with VET providers and employers, facilitates effective communication among them, and enables innovative teaching and learning methods (OECD, 2021[6]). It can enhance training outcomes in VET, streamline assessment and qualification processes, and support robust monitoring of training processes and outcomes. While the COVID-19 pandemic underscored these benefits, highlighting the importance of digital tools in remote teaching, recent advancements in AI have further accelerated the scope and pace of technological innovation within VET.

While ethical considerations and human oversight remain essential (see Section 3), responsible use of innovative technology can transform VET Collaboration among VET professionals, industry and EdTech companies further drives innovation by ensuring tools are relevant, accessible, and cost-effective.

In addition, such technology use can have significant implications for learners with learning difficulties, providing adaptable, accessible and supportive tools that cater to diverse learning needs. Virtual and augmented reality can offer immersive, hands-on experiences, making complex tasks easier to understand through audio-visual and interactive cues. Adaptive learning platforms using AI can personalise instruction based on each learner's pace, strengths and weaknesses, helping to keep them engaged and supported. For learners with reading, processing or physical challenges, tools like speech-to-text and text-to-speech applications and wearables provide alternative ways to engage with content and practice, while interactive simulations allow for practice in safe, controlled environments without fear of mistakes (OECD, 2021[17]; OECD, 2023[1]). Together, these technologies contribute to an inclusive VET environment where learners with different abilities can thrive, enhancing their confidence and job-readiness in meaningful ways.

Section 2 in this paper explores the transformative role of technology in VET, from engaging learners, VET providers and employers, facilitating and modernising training processes, to assessing and monitoring outcomes and managing a range of tasks involved in VET (Figure 1). Section 3 provides key policy messages to help Ukraine effectively navigate the integration of technology in VET in the face of complexities of rapid technological advancement and challenges, drawing on lessons from other countries.

This paper builds on previous OECD research on technology use in VET, including: Innovation in VET (OECD, 2023[1]), Promoting innovative pedagogical approaches in VET (OECD, 2021[6]) and Apprenticeships and the digital transition: Modernising apprenticeships to meet digital skill needs (Cedefop/OECD, 2023[18]) as well as VET country reviews that featured this policy area, for example

Innovating apprenticeships in Scotland (OECD, 2022[5]), and the OECD Digital Education Outlook reports. The definitions of the technologies mentioned in this paper are outlined in the Box 3.

Box 3. Trends of innovative and emerging technologies in educational practices

Several recent reports identified innovative and emerging technologies in educational practices and pedagogies. For example, the 2018 report 'Artificial intelligence and emerging technologies in schools' from the University of Newcastle, Australia, identified three types of technologies based on a range of existing reports: artificial intelligence (AI), virtual reality and augmented reality (V/AR) (Southgate et al., 2018[19]). In 2020, the report 'Digital Learning Innovation trends' from the Online Learning Consortium identified a range of technological trends including: massive online open courses (MOOCs), learning management systems (LMS) and interoperability, open education resources, VR, and AI as well as related educational practices including adaptive learning, gamification and game-based learning, and blended learning (Joosten et al., 2020[20]). Education Scotland (2021[21]) identified 'Emerging technologies, emerging practices in education', highlighting V/AR, mobile learning, AI, learning analytics, 3D printing, live streaming, learning games and simulations, wearable technologies, MOOCs, robotics, and drones. The range of practices for these technologies included: streaming of live lessons, accessing recorded lessons, collaborative learning, supporting learning through social media, learning in immersive virtual environments, hybrid/game-based/mobile learning, and the use of open education resources. The 2023 EDUCAUSE 'Horizon Report, Teaching and Learning' noted the growing potential for AI, blended learning, micro-credentials and no-code technologies that simplify complex processes.

This report mainly focuses on the following technologies:

- **Online course** is a form of education carried out through a connection to the Internet. A teacher may deliver training in a range of formats, using digital tools and content like live video streaming, recorded videos, eBooks, e-learning tools and software and webinars. It can use video conferencing platforms, mobile learning applications and online learning platforms such as LMS that support the creation, delivery, and tracking of online courses. Online courses are usually accessible to a wide range of students from anywhere, ideal for areas with limited educational infrastructure. While some are available for free, others are not.

- **Immersive/enveloping technologies** include 3D videos, virtual, augmented and mixed reality (AR/MR) and games and gamification. VR allows students to simulate real-world environments and scenarios through computers and simulations and interact with an artificial 3D visual and sensory environment. AR/MR enhances and mixes real-world settings with digital overlays, providing interactive learning opportunities in a real context. Games and gamification take elements from game-design, applying them to educational contexts to provide learning opportunities while increasing engagement and motivation.

- **Simulators** allow learners to develop their ability to confront real-life challenging scenarios. For example, in the logistics and transportation sector, learners use simulators to learn how to drive a truck or operate a loader vehicle facing real-life issues. The maritime sector uses simulators to train apprentices in the navigation and operation of vessels, both at sea and in ports.

- **Robots** are a physical machine with sensing, computing and actuating capabilities, able to carry actions automatically. Often robots can make autonomous decisions and can adapt these decisions based on prior knowledge and sensor input. Robots can interact and collaborate with learners, and can be programmed to personalise the assistance based on learner needs.

- **Learning/data analytics** is one of the new young disciplines in data science. It studies how to employ data mining, machine learning, natural language processing, visualisation, and human-

computer interaction approaches among others to provide educators and learners with real-time insights that might improve learning processes and teaching practice.

- **AI** is a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy. AI can personalise learning experiences, offer intelligent tutoring systems, and provide analytics for student performance. When combined with sensors and LMS, AI can give teachers a sense of how different students learn and advance and help teachers, especially novice ones, read the classroom better and adjust the speed of teaching or stimulate students with adequate techniques. AI can also help integrate real-time data and feedback in assessment and identify students who may benefit from an accelerated or a slower learning pace.

- **Blockchain** combines existing technologies that together can create networks that secure trust between people or parties who otherwise have no reason to trust one another. The marriage of these technologies enables a secure transfer of value and data directly between parties. Specifically, it utilises distributed ledger technology to record and store information verified by cryptography among a group of users, which is agreed through a pre-defined network protocol, often without the control of a central authority. Instead of one authority controlling this ledger (like a bank), an identical copy of the ledger is held by all users on the network, called nodes. Along with its own hash, each block stores the hash of the block before it. A hash is a unique string of letters and numbers created from text using a mathematical formula. Blocks are therefore "chained" together, making the ledger (almost) immutable or unable to be changed. Blockchain has potential to bring skills and qualifications together in a reliable, user-friendly credential system, where reskilling and upskilling could be facilitated.

- **School Information System** (SIS) is a web-based platform that helps schools manage student and teacher information and data online. The SIS collects school-wide data online (e.g. student information, grades, records of tests, attendance, appraisal performance, teacher absence) that can be easily accessed by teachers, parents, students, and administrators. It can also facilitate teacher collaboration and teaching tasks. For example, teachers can share and use lessons and teaching material that are stored in a centralised location in a database or on a server.

Source: OECD (2023[3]), OECD Digital Education Outlook 2023, https://doi.org/10.1787/c74f03de-en; OECD (2022[5]), Strengthening Apprenticeship in Scotland, https://doi.org/10.1787/2db395dd-en; OECD (2021[17]), OECD Digital Education Outlook 2021, https://dx.doi.org/10.1787/589b283f-en; OECD (2021[6]), Teachers and Leaders in Vocational Education and Training, https://dx.doi.org/10.1787/59d4fbb1-en; OECD (2023[1]), Building Future-Ready Vocational Education and Training Systems, https://doi.org/10.1787/28551a79-en; European Commission (2023), European Education Area Strategic Framework Working Group on Digital Education: Learning, Teaching and Assessment PLA, 30 May – 1 June 2023. Input paper: Emerging technologies and related educational practices, https://ec.europa.eu/transparency/expert-groups-register/core/api/front/document/99147/download.

2 How can innovative technologies transform vocational education and training?

This section explores the potential roles of technology in VET, with various aspects in which technology can be put to use broadly classified as: engage, train, assess and manage (Figure 1). For example, technology can be used to better match learners with training opportunities, and to identify individuals and employers that could benefit from VET opportunities (*engage*). It can help provide learning in simulated work environments, and support training for learners with special needs (e.g. learners with physical and/or learning disabilities) (*train*). It can assist in assessing VET outcomes, and help align VET with (local) labour market needs (*assess*). Technology can also be used to facilitate information exchange between learners and training providers and assist with administrative tasks (*manage*). This section delves deeper into these four dimensions, providing concrete examples of technology applications and use in VET.

This framework and the examples presented can support Ukraine in developing a strategy for effective technology adoption and use in its VET system. It provides a holistic overview of the various areas in which technology could enhance VET in Ukraine, in the short and long term. The overview can support the Ministry of Education and Science, and especially its Directorate of Digital Transformation in Education (see Box 2), in identifying current gaps in technology use and set priorities. In the short-to-medium run, the priority might be on ensuring access at times of disruption and personalising training (including for war veterans and learners with disabilities), but in the longer run the engagement and management aspects will become equally important.

While the examples presented in this section can serve as inspiration, and potential partnerships could be explored, VET stakeholders looking to adopt similar tools need to take into account the realities of the Ukrainian VET system to evaluate whether a particular tool or solution can be effective in Ukraine and what adjustments might be needed. For example, the existing platforms in Ukraine presented in Box 2 could be augmented with further innovations to better engage, train or assess learners, and the international examples presented in this section could have characteristics that could serve as inspiration, even if they are not fully compatible with the platforms. The next section further discusses enabling conditions and policies that are essential to ensure effective technology adoption in VET in Ukraine.

Figure 1. The potential role of technologies in VET
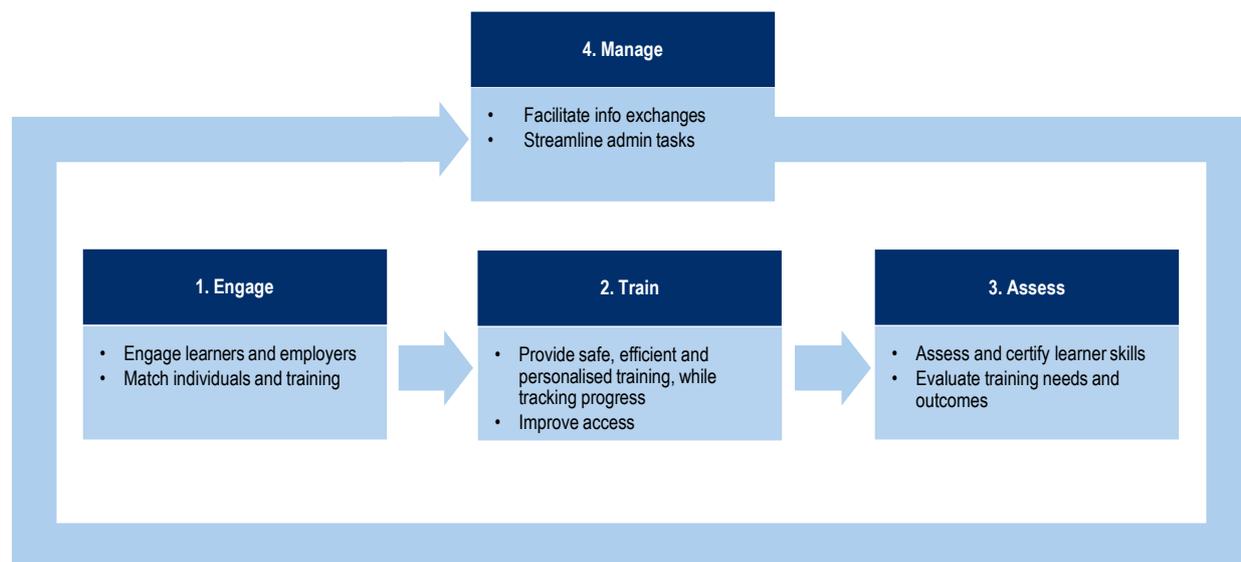
Source: Adapted from OECD (2023[1]), Building Future-Ready Vocational Education and Training Systems, https://doi.org/10.1787/28551a79-en.

2.1. Engaging in VET

Technologies can help engage learners and employers – key actors – in VET programmes. Data analytics and artificial intelligence (AI) can greatly enhance engagement in VET by increasing relevance to learners and employers, while profiling systems create detailed learner profiles and help VET providers offer tailored training programmes that align with individual needs and career goals. For employers, these technologies can identify workforce skill gaps and enable targeted upskilling initiatives. By facilitating the match between learners, employers and VET providers, these tools support more relevant, effective and responsive skills development.

Leveraging data and digital tools to engage learners in VET

Data analytics, statistical profiling models and AI can significantly enhance how learners engage with VET programmes. These technologies collect detailed data on individuals' interests, strengths and weaknesses, and possible skill gaps, that can be used to create individualised and tailored profiles (OECD, 2022[5]). These profiles can help VET providers identify individuals who could potentially benefit from VET opportunities, and find the most suitable programmes and learning support for each learner. This can make outreach efforts more personalised and relevant to individual needs and goals. Profiling systems using AI are widely used in public employment services for unemployed individuals and jobseekers (Broecke, 2023[22]), with AI-driven tools able to pinpoint skill gaps, and provide targeted recommendations for upskilling, which supports career development. Such an approach has the potential to make VET more appealing to a larger group of learners, as (prospective) learners see how training directly aligns with their career aspirations.

In addition, countries have increased the delivery of career guidance programmes through digital technologies during the pandemic, including online career talks, virtual job fairs and work placements as well as career chatbots, which help to motivate learners to engage in VET (OECD, 2024[23]). Similar types of technologies can be also used to identify VET students at risk of dropping out, using the administrative micro-data that are increasingly being collected by education systems. While identifying a good set of early

warning indicators remains difficult, a few systems have shown a high level of accuracy (OECD, 2021[17]). These techniques may help prevent students from dropping out, detect potential problems, and provide opportunities to intervene earlier.

Example of technology applications used to engage learners in VET in OECD countries include:

- In the United Kingdom (UK), apprenticeship management applications such as *aptem*® offer initial and diagnostic assessment, including a prior learning calculator, to identify learners' diverse needs and connect to appropriate apprenticeships. Most of the functions are automated to collect and analyse data to provide necessary and targeted information and insight. *aptem*® provides data analytics with built-in machine learning functionality and identifies issues among programmes or learners through its early warning system. It generates data to assess the pace, progress and engagement levels of personalised learning, helping educators intervene proactively (OECD, 2022[5]).

- In Switzerland, the DUAL-T Leading House, a research project funded by the Swiss State Secretariat for Education, Research and Innovation (SERI) that studies how technology can be used in the dual-training in both school and work environments, developed tools to explore behavioural patterns of students, predict their performance and help them to succeed. For pre-class activities, this design makes use of videos and digital content in online platforms. The students' engagement in pre-class activities prepares them for effective participation in in-person sessions. While the pre-class scheme was developed primarily to increases students' success rates during classroom teaching, it also contributed to development of a model predicting students' performance. The model draws on digital traces left by students during their online interactions with pre-class activities. The widespread use of the scheme allowed researchers to investigate these interactions and, on this basis, predict students' performance (OECD, 2023[1]).

- *CiCi* the AI careers chatbot in England (United Kingdom) supports personalised career exploration for learners by giving them access to current and relevant careers and training information in a single place. It can be translated into different languages and has a text-to-speech function to support individuals with different learning needs. It brings a wide range of potential pathways to life, including CV templates, skills, vacancies, apprenticeships, and courses etc, with videos of people in a wide range of job roles, including entrepreneurs. The bot information is aligned with the English national inspection framework for schools and quality standards. A live, personalised and tailored dashboard complements the *CiCi* bot by capturing key user data, including gender, ethnicity, age, search patterns and top-searched occupations, time of the day usage, and the number of users requesting direct assistance from a human adviser. These dashboards of metrics use Application Programme Interfaces (APIs) and machine learning that provides comprehensive data analytics to help align service provision with the reality of the types of searches and occupations individuals are exploring (OECD, 2023[24]).

Engaging employers in VET by more efficiently and timely identifying training needs

For employers, data analytics and AI can be leveraged to assess the skill levels and gaps within their workforce, revealing areas where further training could improve productivity. By identifying these gaps, employers can more effectively partner with VET providers to deliver targeted training programmes that address specific needs. This data- and technology-driven approach ensures that training initiatives are aligned with the demands of the employers, optimising employee performance and upskilling efforts. Moreover, AI can help employers monitor the progress of their workforce's skill development and work performance, enabling more strategic planning of workforce upskilling, recruitment and restructuring.

- The above mentioned aptem® application in the UK enables training providers to use data-driven insights to align training programmes with employers' specific needs, ensuring relevance and impact. By ensuring compliance with national standards imposed by funding organisations and the

auditing body of training providers, aptem® addresses employer concerns regarding regulatory adherence, further encouraging their engagement in training (aptem, 2023[25]).

- Multiverse is an online platform that integrates apprenticeships and digital skills training with employer partnerships in the United Kingdom and the United States. It helps match learners with VET opportunities while helping them develop practical, hands-on experience and offers apprenticeships and skill development programmes in various fields, particularly focusing on digital skills and emerging industries. Apprenticeships are paired with structured learning modules designed in collaboration with employers to align closely with industry needs, ensuring that learners are equipped with the relevant skills. Each learner is paired with a mentor who provides guidance and feedback throughout the apprenticeship. This platform also fosters closer collaboration with employers to create training opportunities that not only fill the skills gap but also directly contribute to the professional growth of learners (Multiverse, 2024[26]).

Matching learners, employers and VET providers through innovative technologies

Technologies can play a crucial role in matching learners, employers and VET providers through online platforms that connect learners with relevant, potential VET providers and employers. By utilising innovative tools such as profiling tools, matching algorithms, artificial intelligence and machine learning, these platforms can be used to analyse user preferences, skills and (real-time) labour market demands. This can help enhance the efficiency of the matching process, reduce search and matching costs and align skill needs and training (OECD, 2023[1]).

Examples of platforms that aim to better match learners with VET opportunities and employers include:

- In Finland, Studyinfo (*Opintopolku*) helps match learner interest and needs with education and qualification programmes. It provides information on education paths, VET programmes and providers, and application procedures and allows learners to explore and apply for VET opportunities that match their interests, needs and qualifications. VET providers can manage their offers, while policymakers can use the platform's data to monitor trends and alignment with policy goals. While it does not provide analytics on skills needs and gaps, or directly connect to employers, its VET section provides information and insight into programmes that address labour market demands (Studinfo, n.d.[27]).

- Scotland's (United Kingdom) comprehensive online apprenticeship portal (apprenticeships.scot) and Norway's new online portal for apprenticeships (finnlaerebedrift.no) offer services to connect apprentices and employers, and provide an overview and detailed information on apprenticeship jobs, study fields, enterprises offering apprenticeships and funding opportunities, and general guidance and advice on apprenticeships (OECD, 2023[1]).

- In the Netherlands, the Ministry of Education, Culture and Science developed a VET programme choice portal (kiesMBO.nl) that provides detailed information on the different fields and career pathways. The portal includes a matching game helping students navigate through all the VET options and find the programme that corresponds best with their interests and context. It helps learners explore various career pathways, understand the skills required, and identify suitable training opportunities aligned with their interests and goals (OECD, 2023[1]). By offering an intuitive interface and personalised recommendations, this platform facilitates informed decision-making and ensures students are matched with programmes that fit their aspirations and local job market needs. Being integrated into this platform, MBOStad takes a gamified approach to career exploration for VET students. It allows learners to virtually navigate different career options within a simulated city environment, interacting with various industries and job roles. By integrating real-world scenarios, MBOStad fosters engagement and provides insights into potential career paths. Additionally, it strengthens the connection between learners, VET institutions, and employers by highlighting opportunities for internships, apprenticeships, and employment (DTT, n.d.[28]).

Technology-supported profiling and matching tools are also used commonly by public employment services to match jobseekers with jobs and/or training opportunities, for example:

- Flanders (Belgium) uses a deep learning model based on real-time labour market data and job seekers' skills data to connect learners to VET opportunities. The Flemish Employment and Vocational Training Service helps residents of Flanders find jobs and take vocational training, by using machine learning (OECD, 2023[1]).

2.2. Training in VET

Integrating advanced and innovative technologies in VET can improve the accessibility and effectiveness of training. These technologies allow learners to gain hands-on experience in a safe, cost-effective, and scalable way, particularly in high-risk and resource-intensive sectors. Immersive technologies provide simulations of real-world environments for VET, enabling learners to practice critical skills without the need for expensive equipment or hazardous conditions and fostering better learning outcomes. Additionally, adaptive learning technologies are personalising VET by adjusting the pace, condition and difficulty of lessons, supporting learner' individual needs.

Providing safe and efficient learning environments, with better learning outcomes

One of key features of VET is to combine classroom knowledge and hands-on practice. By leveraging immersive tools like Virtual Reality (VR) and Augmented Reality (AR), training providers can offer learners practical experiences that closely mimic actual job environments, enriching the learning experience and better preparing learners for workforce demands (Dillenbourg et al., 2022[29]).

These technologies are particularly useful in vocational fields in which training activities face health and safety concerns, involve wasteful resource use, and/or require expensive specialised equipment, as for example in healthcare, construction and aviation. For example, VR-based surgical simulators and AR tools are used to train healthcare practitioners in complex procedures, providing safe and engaging learning experiences (Tang et al., 2022[30]). Technologies such as VR/AR eliminate in some cases the need for expensive equipment or facilities, making training more affordable and scalable (Ravichandran and Mahapatra, 2023[31]). Additionally, immersive technologies offer economies of scale, allowing these resources to be shared across multiple institutions. Employers also benefit, as these technologies reduce the amount of time new trainees need to work with real equipment, lowering training costs and providing a cost-effective complement to traditional work-based learning.

The benefits of these tools go beyond safety and cost-efficiency: studies show that these technologies can enhance learning outcomes. Research on VR training in the fields of healthcare, safety, and engineering find better results in developing technical, practical, and socio-emotional skills than traditional methods. For example, a meta-analysis assessing the effects of VR training across 31 primary studies including these sectors found that VR-trained students used inputs and time more efficiently and showed higher accuracy, scoring approximately 3% higher in technical assessments for every additional hour of VR training, compared to traditional training (Angel-Urdinola, Castillo-Castro and Hoyos, 2021[32]). Several other meta-analysis also prove the effectiveness of immersive technologies in surgical training programmes, helping learners obtain a higher performance score, but with no significant difference in the time needed to complete the surgery compared to a traditional training (Guedes et al., 2019[33]), although with some inconsistency in performance across examined studies depending on the skills evaluation setting (Piromchai et al., 2015[34]; Tang et al., 2022[30]).

In addition to developing technical skills, utilisation of technology in VET schools, such as robotic technology, can also serve the development of computational thinking, creativity, innovation, communication, and teamwork skills among students (Sukardi, Risfendra and Doni Tri Putra, 2024[35]).

Moreover, gamification and game-based (GB) learning, using mechanics such as point scoring and challenges, can make the learning process more engaging through interactive modules and skill-building simulations (OECD, 2021[17]). For example, a user survey among undergraduate engineering students showed that a GBVR training has higher system usability and user-friendliness in terms of visual output and knowledge retention than paper-based training due to visualisation technologies and motivational and engagement factors (Beh et al., 2021[36]).

Many countries are increasingly leveraging different technologies to deliver training and increase training effectiveness. For example:

- In Switzerland, VET schools have used interactive technologies for many years, for example those developed by Leading House Dual-T (described above). These include, for example, *Tinker*, a tool designed to support hands-on learning through interactive technology. It includes *TinkerTable,* a smart workbench with sensors that track objects, allowing learners to manipulate real objects and see relevant digital information projected onto the workspace, as well as *TinkerLamp*, an overhead projector that works with these tools, visually augmenting tasks to help learners understand complex steps in a more intuitive, hands-on way. These tools help create an interactive workspace that combines hands-on and digital learning by making visible/possible something that is normally invisible/impossible in the real world (Dillenbourg et al., 2022[29]).

- Also in Switzerland, the GardenVR application allows gardener apprentices to practice landscape and garden design in a virtual space. It enables them to visualise and modify garden layouts in real-time, experiment with different designs, and understand spatial relationships without the constraints of physical materials or outdoor environments. This approach provides a safe and creative setting for honing design skills while reinforcing eco-conscious planning principles. A research experiment with 30 gardener apprentices in Switzerland shows the effectiveness of such an immersive virtual reality (IVR) application in developing designing skills. By creating immersive environments, IVR captures learners' attention and foster higher engagement through interactive, realistic simulations and personalised, experiential learning experiences (Kim et al., 2020[37]).

- In the United States, many learning platforms offer practical solutions by providing immersive, online training for skilled trades. For example, Interplay Learning offers VR, 3D simulations, and video-based courses, focusing on fields such as HVAC, electrical, plumbing, and facilities maintenance for VET learners to practice and enhance skills in safe, repeatable environments without requiring physical equipment, while tracking their learning progress and certifications. According to Interplay Learning, 89% of users reported faster training times, helping companies or VET providers develop skilled technicians more efficiently (Interplay, n.d.[38]).

- In the Republic of North Macedonia, a VR training programme, Virtual Reality Skills Lab, for 300 future electro-technicians was introduced in five VET schools in 2021. The VR application transfers VET students into a digital factory floor or construction site and helps them practice protection in work settings with high voltage levels, work with tools and instruments, and identify and remove simulated defects. A crucial element of this pilot project was a skill needs analysis conducted with companies in the electrical industries and the involvement of the Organization of Employers of Macedonia and the VET schools in the design of the VR tool. Schools were equipped with VR headsets and computers and the teaching staff upgraded their skills (ILO, 2022[39]).

- In France, the École Nationale Supérieure des Métiers de la Viande (ENSMV) developed a digital resource platform in collaboration with the Confédération Française de la Boucherie, Boucherie-Charcuterie, Traiteurs (CFBCT). The platform, aimed at the meat industry, features various innovative and immersive learning tools, including 360° VR training modules for developing soft skills. These tools are designed to enhance VET in areas like butchery, offering game-based VR and interactive modules to improve technical and behavioural competencies (ENSMV, 2025[40]). In addition, the campuses of trades and qualifications (*les Campus des métiers et des qualifications*) network has become a key player in educational innovation as part of the France 2030

programmes. With 116 campuses covering 12 strategic sectors, including eight specialised in the automotive mobility sector, these hubs respond to the technological, digital, societal and ecological challenges facing the automotive industry. Projects include digital twins, physical and virtual simulation benches, some with augmented reality and virtual factory tours, virtual production lines with augmented reality simulation (support for maintenance and piloting), immersive dome, 360° video, 3D scanner, serious game, Metavers for safety and/or collaborative work training.

Making VET more accessible

Technology can improve access to VET by overcoming traditional barriers such as geographic constraints. Online and virtual learning can improve access for learners in remote areas by providing remote connections to VET providers and employers – as long as internet connectivity is up to standard. Other types of technology can make VET more accessible to students with special needs or disabilities that may have prevented them from following certain pathways in the past. For example, AI systems can help learners overcome obstacles to learning, such as through text-to-speech or speech-to-text applications or wearables to help visually impaired students read books (Vincent-Lancrin and van der Vlies, 2020[41]). Assistive technologies and wearable devices such as eye-tracking software, voice-activated systems, and smart/robotic exoskeletons can support individuals with disabilities. These innovations not only aid rehabilitation but also enable participation in technical training, minimising barriers for those with mobility challenges or traumatic injuries.

- In Scotland (United Kingdom), the Open University (OU) works with employers to offer online Graduate Apprenticeships in high demand fields such as cyber security and software development. Learning material includes online activities, eBooks, video and audio resources, *OU Anywhere App*, and face-to-face and online tutorials. The OU provides apprentices with a support network: an apprenticeship programme manager, practice tutor, line manager/mentor, academic tutor and student support team. It also provides pre-programme learning and induction (OECD, 2022[5]).

- In Dallas (Texas, United States), Virtual Internship Programs provide paid, online work experiences for students to contribute to local companies. Typical high school virtual internship experiences are 120 hours spread over four weeks in the summer. The Program aims to provide participants with opportunities to gain hands-on experience, develop professional skills, and build networks within various industries – all from a remote setting. These programmes typically include partnerships with local businesses, organisations, and educational institutions in the Dallas area. Dallas also provides a *Virtual Internship Toolkit* to facilitate high-quality virtual internships, focusing on practical, scalable strategies as well as resources like checklists, templates, and implementation tips for educators and employers, which can also be adapted for in-person internships (Advance CTE, 2021[42]).

- In the EU, the Erasmus+ WEAVE project aims to equip post-secondary VET providers with resources on accessible web design for learners with disabilities and enrich the professional competences and the employment prospects of web developers, among other objectives. It simplifies web navigation for people with visual, cognitive or learning disabilities to enhance VET accessibility (WEAVE, 2024[43]). Another project, the ALL43D, aims to equip VET trainers and other professionals working with young people with disabilities to upgrade their professional profiles concerning the introduction of emerging technologies in education, especially 3D modelling, design and printing linked to social entrepreneurial skills for sustainable development and green transition (European Commission, 2022[44]).

Personalising VET through adaptive and tailored learning

VET learners have diverse skills, aspirations and needs, and some have physical disabilities and cognitive impairments. Personalised and adaptive approaches can help learners reach their full potential.

Adaptive learning technologies personalise the learning experience, adjusting activities and difficulty based on a learner's strengths, weaknesses, progress and needs but still within the curriculum, which enhances engagement and reduces dropout rates. Advanced systems can even detect and address learner disengagement, ensuring continuous, effective learning. In particular, AI-driven tools can provide critical insights to tailor learning activities and pedagogical strategies for teachers by analysing standardised assessment data and learner interactions (OECD, 2023[3]). Early warning systems predict risks like dropout, enabling timely interventions. These tools also generate personalised recommendations and facilitate real-time tracking of progress, allowing instructors to adapt resources and strategies dynamically. Immediate feedback from training platforms can help refine learning approaches, while social robots and intelligent tutoring systems can offer emerging solutions for motivation and support (OECD, 2023[3]), which could be particularly helpful for veterans.

The integration of these technologies into VET programmes creates more inclusive and equitable opportunities, ensuring that learners with diverse needs can access high-quality, personalised training. By leveraging AI, immersive tools, and assistive devices, VET institutions can foster skill development of a broader population and their successful transitions into the workforce. There are several country examples that leverage the benefit of different technologies with different goals.

- Intelligent Tutoring Systems (ITS) utilise AI technology to provide adaptive, personalised learning experiences. Although prevalence of such systems remains relatively low on average among OECD countries, they are becoming more common. In the Netherlands, the education system has embraced various ITS developed by EdTech companies primarily for Dutch language and mathematics. These ITS craft adaptable lessons from the analysis of student workbooks and inputs from teachers across the country and support interactive teaching, immediate feedback, and varied tasks for different skill levels. In addition, applications like Flexi, Rekentuin, Taalzee, and Words&Birds employ advanced algorithms and data-driven analysis to provide students with customisable exercises, extensive instructional materials, progress tracking, and direct feedback, so they can benefit from access to exercises tailored to their skill level and real-time error correction (OECD, 2023[3]).
- Estonia developed the Triumfland Saga wellbeing game (Triumf Health), a personalised mental health and wellness learning game for students in primary and secondary education and adults. The game provides personalised content, adapting to each learner's needs, backgrounds and progress, ensuring an individualised learning journey that resonates with their unique strengths and challenges. Grounded in scientific research, the game's methodology ensures that learners receive accurate and effective mental health education, enhancing their emotional intelligence and coping skills (Triumf, 2024[45]).
- In Switzerland, the DUAL-T Leading House project, already mentioned, analyses student performance to personalise learning by adjusting the speed and content to individual needs, so as to cater to students with lower academic performance facing a higher risk of dropping out from school. The adaptive pre-class model leverages data on student interactions with digital content to predict outcomes and adjust teaching strategies, helping instructors address learning gaps early. These early predictions facilitate effective content personalisation and adaptive teaching interventions (OECD, 2023[1]).

Personalising and tailoring learning provision requires solid monitoring of training activities and outcomes. Technology can help track learning activities, processes and progress throughout VET. Mobile logbooks allow VET learners to record and demonstrate their learning and training progress, including details such as hours worked, tasks performed, and equipment used. Learner management/tracking systems, where teachers and trainers have detailed information on learners, can improve the quality of training provision, similar to the player-level analytics available to a professional sports coaching staff. Such systems can provide teachers and trainers with information that they may have neglected during lessons due to their workload or other systemic, technical, or institutional issues. By leveraging data analytics, VET institutions

can track student progress, identify skill gaps, and offer personalised learning paths. These learner management systems are further discussed in the subsection on "Managing in VET".

2.3. Assessing in VET

Technology can create innovative, cost-effective, and predictable ways to assess and certify skills. Digital and smart technologies are increasingly being used in the assessment of VET outcomes, including in apprenticeships, and in compiling and evaluating e-portfolios of skills. Beyond assessing individual outcomes, data- and technology-supported innovations can also be used to measure outcomes at the programme, provider or system level that can serve to enhance the quality and relevance of VET provision.

Assessing learner skills using digital assessments

Technology is transforming how VET institutions and employers assess learner skills and outcomes, offering innovative approaches that go beyond traditional and conventional paper-based exams. Digital assessments in VET, for instance, provide deeper insights into student competencies by measuring skills through various digital formats. Digital or online assessment platforms and tools can streamline the exam process and reduce the work of assessors by automating the creation of exam question and tasks and consolidating exams to test a series of competence-based tasks (Cedefop, 2022[46]). Advanced tools and approaches further expand the scope of skills assessed. For example, game-based assessments measure creativity, collaboration and adaptability, while digital simulations allow assessing practice-oriented skills of VET learners. Smart technologies and smart data analysis can capture time management and response strategies of test takers, using eye-tracking and time-on-task data, audio recordings and natural language processing (OECD, 2021[17]). These nuanced metrics give VET teachers a comprehensive view of each student's strengths and areas for development, enabling more precise assessments and targeted feedback. These digital assessments can lower the administrative costs associated with grading and reporting while enhancing efficiency and accountability in the VET system.

Examples of technology use in VET assessment include:

*   In Germany, the ASCOT (Technology-based Assessment of Skills and Competences in Vocational Education and Training) research initiative was launched by the Federal Ministry of Education and Research in 2011. It aimed to develop valid methods for the technology-based assessment of vocational skills and competences at the end of VET. The initiative involved several co-operative projects between experts in the fields of science and practice and developed assessment instruments based on real-life situations. For instance, apprentices in mechatronics had to diagnose engine defects in computer-based simulations. Apprentices training to be medical assistants were confronted with a virtual doctor's office simulating real-life scenarios and interactions with patients. The ASCOT instruments proved highly suitable for the assessment of large areas of occupational competence such as technical and professional competences, occupation-specific social and communication skills, and occupationally relevant literacy and numeracy skills. The instruments also increased the objectivity of assessments, improved the test motivation of examinees with the use of multimedia and interactive content, and were more efficient than traditional assessment instruments. Since 2018, the follow-up initiative ASCOT+ has been developing digital measuring instruments for professional and cross-professional competences and testing them as teaching and learning media and in examinations (OECD, 2022[5]).

*   In Switzerland, the above-mentioned Realto platform integrates digital technology to assess the skills of VET learners by providing advanced evaluation tools aligned with industry standards while emphasising close collaboration between vocational schools, companies, and professional organisations. Through digital assessments, Realto supports both competency-based evaluations and the identification of skill gaps, enabling tailored training pathways. The platform allows learners

to demonstrate practical and theoretical knowledge in simulated or real-world scenarios, ensuring alignment with labour market needs while offering flexibility for students with diverse learning paces and conditions (EPFL, 2023[47]).

Certifying acquired skills

Technology can enhance the certification process in VET by introducing secure and portable digital credentials, especially through blockchain. Blockchain technology is opening new avenues for credentialing in VET as a form of "verification infrastructure". Blockchain technology creates verifiable, tamper-proof digital certificates, which add reliability and security to skill credentialing in VET. Unlike traditional diplomas, blockchain-based credentials are instantly shareable and universally recognisable, facilitating movement across different locations, training institutions and workplaces. Employers can trust that blockchain-verified credentials accurately reflect a candidate's abilities, which can streamline the hiring process. Blockchain credentialing systems also reduce administrative costs, prevent fraud, and offer individuals increased control over their own data. Many blockchain initiatives are underway around the world, which may transform how VET systems – as well as entire skills systems – manage and verify degrees and qualifications (OECD, 2021[17]).

- In multiple European countries including Greece, Portugal, and the United Kingdom (UK), a project called, QualiChain (Decentralised Qualifications' Verification and Management for Learner Empowerment, Education Reengineering and Public Sector Transformation) (2019-21), leveraged blockchain technology to transform the way educational and employment credentials are managed, verified, and shared. It aimed to manage and verify educational and employment credentials within the EU to facilitate cross-border education and career mobility. For example, the Knowledge Media Institute of the Open University led the project to address challenges in verifying qualifications across diverse educational systems and institutions. By creating a decentralised, open-source and secure platform, the project aimed to capture, archive and manage learners' data, making it easier for employers and educators to verify and validate qualifications quickly and accurately (OECD, 2022[5]). The QualiChain platform also provides career counselling, intelligent profiling, and competency management. These tools assist learners in tracking their skills development and make career or educational recommendations based on their current profiles. The platform was tested through various pilot programmes focusing on lifelong learning, smart curriculum design, and public sector recruitment processes (European Commission, 2022[48]). For example, the Greece's pilot 'Staffing the Public Sector' aimed to provide personalised candidate notifications for job vacancies by matching individual profiles with available jobs in the civil service, validate qualifications of individual candidates and improve the efficiency of the recruitment process in terms of time and credibility.
- VALID-8 is a vocational assessment platform designed to evaluate and certify skills, using multimedia evidence and AI. It builds e-portfolios to demonstrate skills, analyse performance and cross-references training gaps. VALID-8 allow users to demonstrate that they have met a requirement with real and relevant content, including video, audio, images, documents, testimonies, certificates, and comments that can be uploaded and linked to specific learning criteria. The platform can also be used to identify gaps in training and generate development plans. It is being used in the United Kingdom, Canada and other countries (Vametric, n.d.[49]).

Evaluating VET outcomes and skill needs

A data-driven approach including information about VET outcomes can help improve the quality of VET systems. Coupled with data on labour market demand, such information can enhance the responsiveness of VET systems to changing skill needs. Designing a relevant VET offer requires identifying current and future labour market needs and skills requirements, determining training needs and developing these into

qualifications, qualification requirements, curricula and training courses as well as updating these in a timely manner. In this context, technology can improve the monitoring and evaluation of quality and outcomes in the VET system, by providing more accurate, timely and detailed information on the labour market outcomes of learners and employers' skill needs. Advanced analytical approaches and technologies and big data can facilitate the collection and analysis of detailed and large-scale labour market trends, including real-time insights into skill demands from online job postings. This wealth of data allows granular analysis by sector, occupation, and region, providing actionable intelligence for redesigning and updating the range and content of VET programmes. Integrating big data with traditional sources, such as labour force surveys, supports curriculum designs and updates, career guidance and resource allocation, ensuring alignment with evolving employers' skills demand (Cedefop; European Commission; ETF; ILO; OECD; UNESCO, 2021[50]; OECD, 2022[5]; OECD, 2023[1]).

Several examples demonstrate how leveraging data analytics can support the quality assurance of VET and improve VET responsiveness to changing labour market conditions.

- In the United States, O*NET (Occupational Information Network, a comprehensive database of worker attributes and job characteristics in the United States) serves as a data analytics platform for understanding job characteristics, required skills, educational qualifications, and labour market trends by collecting data from multiple sources, including job incumbents, employers, and occupational experts. O*NET includes tools to map occupations to educational programmes, certifications, and training opportunities. O*NET uses machine learning and natural language processing (NLP) techniques to analyse job descriptions and related textual data, extracting key information about skills requirements and occupational interest (Putka, Dahlke and Burke, 2023[51]; Dahlke and Putka, 2021[52]). For instance, O*NET identified green occupations in the context of green transition. O*NET is also exploring the use of Artificial Intelligence (AI) including large language models (LLMs), such as Generative Pre-Trained Transformers (GPTs), ChatGPT, as sources of additional information (Lewis and Morris, 2024[53]).

- Open Syllabus Analytics, a large nonprofit project that compiles over 20 million syllabi from universities worldwide, offers tools to explore course materials and trends, match courses for credit transfers, and visualise curriculum connections. It uses data aggregation (web scraping and data mining to collect syllabi from global institutions), natural language processing for analysing the textual content of syllabi, identifying subjects, and creating trends; and ML to match courses, predict content overlap, and enhance syllabus classification. This allows learners to get insights into training content, learning providers to refine their curriculum in response to labour market needs, and policymakers to gain insights on educational trends to support innovation and policy decisions. Similarly, it can be also used to inform and update VET and VET curricula. Based on such information, VET providers and stakeholders could alter the composition of core/optional modules (OS Analytics, n.d.[54]).

Comprehensive data on VET outcomes and skill needs not only help improve the quality of VET, but also support prospective learners in making informed decisions about which VET programmes to enrol in and with which provider (see Section 2.1). Several countries integrate data on student outcomes by programme and/or provider on dedicated websites/portals – albeit with varying degrees of user-friendliness. For example:

- In the Netherlands, the above-mentioned platform KiesMBO provides information on VET programmes, graduation rates, student satisfaction and the employment outcomes of graduates from different institutions, to inform stakeholders and improve the VET system (OECD, 2023[1]).

- In Estonia, the Estonian Qualifications Authority (*Kutsekoda*) maps sectoral and thematic labour and skills needs using both quantitative and qualitative methods, including data from statistical sources, registries, and industry expert consultations. Expert groups monitor the implementation of recommendations and assess future skills trends. Labour and skills forecasts are updated

annually, with a comprehensive report every three years to project long-term labour demand and market developments (Kutsekoda, n.d.[55]).

- Estonia has also built integrated information systems to combine data on student achievement with information on teachers and school contexts, which can be connected to information on labour market outcomes. The country has been managing data on students, schools, study materials, examinations, curricula and teaching staff through the Estonian Education Information System (EHIS), managed by the Ministry of Education and Research. Schools are required to enter the relevant data, such as on students' grades and successfully completed certificates, directly into the system. The system is a personal-identity-based database, where each person is registered with an individual identification number and the data from different sources are connected. Schools can access their school-specific data to monitor their performance and to integrate this information into their management and learning approaches. Aggregated EHIS data are available to the public on an online platform called Educational Eye (*HaridusSilm* in Estonian) and can be used for example to guide students in their educational choices (OECD, 2020[56]).

- Finland upgraded its labour market barometer in 2023 to include information on skills needs, in addition to the previous assessment of the occupations in demand in the economy. It uses regional assessments to ensure that local demands are accounted for and uses a mix of statistical analysis, regional discussions and industry-specific workshops (TEM, n.d.[57]).

- Lithuania introduced its National Monitoring of Human Resources (Nacionalinė žmogiškųjų išteklių stebė sena, NŽIS) in 2016. This system includes data on individuals' qualifications, education, professions, wages and employers, integrating all available data on individuals, in particular administrative data, from different information systems into one platform (e.g. State Social Insurance Fund, State Tax Inspectorate, Public Employment Service, Centre of Registers, Education Management Information System, Residential Register, State Patient Fund). The system also integrates two previous systems: the "qualification map" (how graduates from VET and tertiary education integrate into the labour market) and a "human resource monitoring and forecasting system" (the medium-term demand of human resources based on Labour Force Survey data). All state authorities are obliged to use NŽIS results in decision making in the fields of labour market, education and human resource development (OECD, 2021[58]).

2.4. Managing in VET

Facilitating information exchange, collaboration and co-ordination in VET

Digital platforms, such as online learning management systems (LMS) and virtual collaboration and co-ordination tools, help gather and disseminate knowledge and enable real-time communication across all stakeholders in VET. Such tools can be used to improve co-ordination and communication between the learner and the different learning environments (e.g. school and employer), which can additionally support more effective monitoring of learning activities and progress. These technologies can also provide a space for sharing best practices, curriculum updates and training materials. Furthermore, information-sharing technologies help create strong networks that connect education providers with industry players, enabling upskilling and reskilling efforts to be targeted and effective.

- In Norway, apprentices can provide documents and access government assistance through specialised e-platforms such as OLKWEB. OLKWEB has been optimised for use by training offices (employer organisation assisting individual employers with the provision of apprenticeship training), who are able to follow up on their apprentices and generate reports that document the apprentice's activities and outputs. Learning providers can access the contacts and details of member companies, analyse and monitor the apprentice's progress through curriculum goals provided through traditional means or by films, images and mobile apps, and access details of grants and

general accounting. Apprentices can interact with each other through the system and can use the interface to record meetings and receive information. The employers can monitor the apprentice's progress in off-the-job training (OECD, 2022[5]).

- In Switzerland, the above-mentioned Realto learning platform for dual-VET, was designed to consolidate assessments of learning progress across different learning environments. It facilitates information exchange about apprentices' learning practice between VET schools and companies. As VET schools began adopting MS Teams on a wide basis, it was decided to make direct access to Realto possible through MS Teams directly. Using data collected by Realto, the relationships and networks of apprentices, teachers and trainers in terms of communication and interaction can be analysed (Dillenbourg et al., 2022[29]).

- In addition, there are various platforms in many other countries that facilitate information exchange, collaboration and co-ordination in VET. For example, in the Netherlands, a digital platform (Wikiwijs) enables teachers to find, create, and share learning materials and provides free, customisable resources for VET and other educational levels. Currently, more than 14 000 open learning materials are available for secondary VET (Middelbaar Beroepsonderwijs, MBO). In Belgium, an online network (KlasCement) fosters collaboration among educators through the exchange of teaching materials, ideas, and experiences, including VET. In Korea, an online portal (HiFIVE: Highschool for the Foremost Innovative Vocational Education) connects VET stakeholders and creates an environment for collaboration, resource sharing including information on VET schools, and access to training materials. It provides work-based learning LMS, allows for joint curriculum development, real-time feedback and community building based on a topic of interest.

Automating administrative tasks to better support VET

Technology can be used to reduce administrative and repetitive tasks involved in VET management. These tasks range from collecting, reporting, manipulating and producing data, resource planning and information and communication, to managing admissions and programme allocations, assessment reports and proctoring systems (OECD, 2021[17]). Simplifying and automating these tasks can drastically transform VET to be more efficient and resource-efficient.

Technology can assist VET teachers in preparing not only teaching and pedagogical tasks but also tasks that are not directly related to teaching and pedagogy. These include adapting instructional language, preparing learning materials and exam questions, grading and marking, providing feedback as well as managing the classroom. A recent OECD study shows that teachers spend a substantial portion of their time on non-teaching tasks and responsibilities (OECD, 2024[59]). While administrative tasks accounts for a small share their working time, they are a major source of stress for teachers (OECD, 2024[59]). Consequently, a well-designed and robust system that can alleviate the administrative burden can enable teachers to focus more on teaching, ultimately enhancing the quality of teaching.

Data and information management system using digital technologies, such as School Information Systems (SIS) and Learning Management Systems (LMS), can play a pivotal role in this, consolidating data on students, staff, and resources into a single platform. These systems support the registration of data, facilitate access of students to web resources by creating a single-entry point, and support school management by providing information on student progress, teacher absence and teacher training. Evaluations of these systems show that they can improve access to information and school resources and result in a more efficient administration. They may also contribute to a lower workload among school staff who use ICT technology with confidence (OECD, 2023[1]). This integration reduces the workload on teaching and administrative staff in VET, allowing VET institutions to manage daily operations with efficiency and precision. School Information systems may also store information on student's progress and more broadly on individuals' credentials and education and training milestones (OECD, 2023[1]).

These systems also facilitate apprenticeship management by employers and employer organisations working with apprentices, as in Norway. This can facilitate the communication between the learning venues and allow for a better monitoring of learning activities and progress.

- In Estonia, Praktikal Edu leverages technology to improve teaching efficiency and learning outcomes. The platform integrates tools such as digital simulations, e-learning environments, and automated progress tracking, enabling educators to focus more on instruction and less on administrative tasks. It incorporates features like real-time student progress monitoring and automated reporting systems. These tools allow educators to track learners' achievements and identify areas needing additional support without manually handling large datasets. Moreover, their platform supports adaptive learning by tailoring content to individual learner needs, ensuring a more personalised educational experience. It also simplifying grading and record-keeping.

- The above-mentioned apprenticeship management system in the UK, aptem® offers functions that help manage the apprenticeship programme from start to finish. aptem® identifies issues among programmes or learners through its early warning system, generating rich data to assess the pace and progress of personalised learning. Computer algorithms can use big data to find the patterns which predict an outcome, for example the responsiveness of tutors, determining how quickly work is assessed and returned to apprentices (OECD, 2022[5]; Abrahams, 2018[60]). It manages and ensures compliance with national standards imposed by funding organisations and the auditing body of training providers (aptem, 2023[25]).

3 Key policy messages for Ukraine

The integration of technology into VET has the potential to transform VET stakeholders interaction, training provision and delivery, as well as learning processes, assessment and management in VET (OECD, 2023[3]; OECD, 2023[1]). Moreover, technologies help make VET systems more effective, efficient, and equitable by meeting the evolving needs of labour markets and personalised training demands. However, for countries, including Ukraine, to fully realise these benefits, a fundamental shift in VET processes would be necessary, one that aligns with technological advancements while addressing the unique sectoral and occupational demands of their economy.

For Ukraine, integrating technology into VET is not only about modernising its VET system but also about rebuilding and strengthening the country's workforce for a future-proof post-war economy and society. The process of technology adoption in VET needs to be closely aligned with the country's recovery and reform strategies, ensuring that technological integration supports immediate educational and training needs while building capacity to meet evolving labour market demands and priorities. Ukraine's digital transformation in VET (as highlighted in Box 2) should be an integral part of Ukraine's broader recovery efforts, with particular efforts to support skills development for internally and externally displaced persons, and war veterans. Moreover, the adoption of technology in VET should also be aligned with the country's (long-term) vision for responsible, ethical and secure use of technology and data.

Despite their potential, significant challenges may hinder the effective integration of innovative technologies in VET. Education and training institutions in general often struggle to keep pace with the rapid evolution of technology sectors such as IT, AI and cybersecurity, primarily due to talent shortages and resource constraints (OECD, 2024[61]), which can also impact on the design, development and use of technology in VET systems. Common barriers include high costs of acquiring and maintaining digital tools, insufficient information about available technologies, and a lack of digital skills among teachers. In Ukraine, additional challenges arise from the impact of the ongoing war, which has led to the destruction of necessary infrastructure, the displacement of teachers and learners, and budget constraints. Moreover, accommodating learners with disabilities and war veterans requires more targeted investments in assistive and adaptive technologies to ensure that VET remains accessible to all.

This section outlines key policy messages to help Ukraine address these challenges and leverage technology for VET transformation. Transforming VET with innovative technologies requires addressing numerous priorities. This paper focuses on a concise list of broad policy messages crucial for advancing VET in Ukraine, informed by the framework and examples outlined in the previous section which can guide Ukraine in identifying gaps and setting priorities. However, this needs to happen while keeping the broader objectives in mind and taking into account the unique conditions affecting the Ukrainian VET system. Technology adoption should not be a goal in itself for Ukraine, but rather a means to reach its goal of building a VET system that responds to the needs of learners and the post-war economy.

Crucially, the potential benefits of technology in VET can only be reaped if the right conditions are in place. There are many investments to be made in Ukraine's education system (and beyond), which will require careful consideration of the costs and benefits of technology adoption in VET and of ensuring that any investment made can indeed have the desired effect on learners. Given the financial pressures associated with a budget deficit and rebuilding efforts, prioritisation of investments in technology should focus on scalable, cost-effective and adaptable solutions that enhance access to quality VET, particularly for the

specific target group mentioned above. This includes leveraging existing and new digital platforms such as Ukraine's Profosvita and Mriia platforms to expand online and hybrid learning opportunities. The messages in this section therefore focus on addressing critical gaps in institutional readiness, costs and teacher capacity in the face of technology integration in VET, while promoting innovative, responsible and ethical technology use. These are challenges that Ukraine faces, especially in light of teacher shortages, school infrastructure issues and ongoing vulnerability in both physical and digital security. The messages are framed within three overarching policy messages:

- **Technology advancement and integration in VET requires a strategic approach, investment and collaboration.** Successful integration of technology in VET demands a clear strategy supported by sustainable investment and multi-stakeholder collaboration. Governments, VET institutions, industry players, and EdTech companies should work together to align the use of technologies with learner and labour market needs while ensuring that financial and human resources are available to support this transition. Collaborative frameworks should include joint design and decision-making as well as resource-sharing mechanisms that facilitate the adoption of innovative technologies in a cost-effective and sustainable manner. For Ukraine, while public policies, private sector engagement and collaboration and co-ordination among key stakeholders are crucial to providing the funding, expertise and capacity-building necessary for VET institutions to adopt technology, leveraging international partnerships to secure funding and technical assistance for this transformation is also key.

- **Technology and VET pedagogy should go together:** The effective use of technology in VET requires a VET teaching workforce that is confident and skilled in applying technology and relevant pedagogical approaches. Governments and VET institutions should provide support for teachers to effectively use digital tools and to design pedagogical approaches accordingly to foster engaging and effective learning experiences. Likewise, Ukraine should prioritise teacher training programmes tailored to the needs of VET teachers, building on ongoing efforts such as the training offer for teachers on the Profosvita platform.

- **Ensuring responsible, ethical and secure use of technology and data is key:** As technology becomes increasingly embedded in VET, ensuring the responsible, safe and ethical use of these tools is critical. Transparent standards for data collection, usage, and protection must be established to safeguard the privacy and security of learners, teachers and employers in VET These aspects are of particular importance for Ukraine, given the heightened digital threats from the ongoing war. Moreover, VET institutions and employers should clearly communicate about the limitations of technological tools, particularly in assessment and certification processes, to build trust and ensure fair implementation, while making ethical considerations central to the deployment of technology to avoid misuse or inequity in VET delivery.

By addressing these policy areas, Ukraine can leverage technology as a transformative means for rebuilding and modernising its VET system, ensuring that the system is resilient, inclusive and responsive to the country's evolving socio-economic landscape.

Additional OECD recommendations related to digital education policy across various levels and areas from other publications are summarised in Box 4 below.

Box 4. Summary of relevant OECD recommendations for further insight

Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency

- **Develop a holistic strategic vision to co-ordinate digital education policy**, including the implications of emerging technologies.
- **Ensure that digital technologies are used to promote quality and equity in education**, requiring the adaptation of pedagogical approaches and careful monitoring and evaluation.
- **Align funding models with policy objectives and enabling smart investments in education technology**, addressing inequalities in access to digital infrastructure.
- **Build capacity for digital education at all levels of the education system,** among educators and institution leaders, but also students, parents and administrators.

Opportunities, guidelines and guardrails for effective and equitable use of AI in education

- **Create digital learning infrastructures at a system level** that are accessible to all learners and educators in and outside of school.
- **Make available a set of quality digital learning resources** to teachers and students, accessible in school and at home, while providing guidance about usage expectations.
- **Integrate pedagogical uses of digital learning resources into the professional competencies of educators**, fostering this through initial education, continuous professional development, and collaborative opportunities.
- **Put learners' and teachers' well-being and mental health to the forefront**, including by keeping a good balance between digital activities and human interaction. Ensure that learners, teachers, and other education stakeholders can receive timely human support when they face a problem, and, when appropriate, a **human alternative to the AI-enabled tool**.
- **Co-create AI-enabled digital learning tools**, encouraging the involvement of teachers, students and other end users as co-designers in the research and development process of technology to help ensure the usefulness and use of AI-enabled digital tools.
- **Foster research about the effective use of digital tools in education**, including practice-engaged research projects that allow teachers to innovate in their classrooms, co-design the uses of technology with researchers that evaluate and document the conditions under which technology use works and for whom.
- **Ensure that the collection of data contributes to securing effectiveness and equity** in education **while protecting students' and teachers' privacy**. Ensure that safety and possible algorithmic bias are tested and addressed in their policies.

Source: OECD (2023[62]), Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency, https://doi.org/10.1787/bac4dc9f-en; OECD (2023[3]), OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem, https://doi.org/10.1787/c74f03de-en.

3.1. Technology advancement and integration in VET requires a strategic approach, investment and collaboration

Transforming VET through technologies demands a strategic approach supported by well-designed public policies, active private sector engagement and collaboration and co-ordination among key stakeholders.

Such partnerships are crucial to create an enabling environment for technological development and adoption, which aligns with the evolving needs of VET systems.

Public policy support to establish an enabling environment for integrating technologies in VET

In order to unlock the potential of emerging technologies in VET, countries require a smart and clear strategy to guide the development and use of technologies that are tailored to (emerging) needs in VET. This includes clear messaging from policymakers to highlight the benefits of technology use in VET, guiding VET institutions to prioritise its adoption. Strong policy support is required to encourage and enable technology development for VET, allow providers/systems to select and adapt relevant technologies, and establish needed technological infrastructure in VET. This support involves strategic planning, resource allocation, stakeholder collaboration and monitoring and evaluation, as well as teacher training (see next subsection).

Ukraine should establish strategies for adopting technologies in a way that addresses not only the immediate challenges – that is, ensuring the continuation of VET during the war and rebuilding educational infrastructure – but also future challenges such as modernising VET and ensuring it addresses the diverse and emerging needs of young and adult learners, as addressed in the first section, which ultimately contributes to broader reconstruction and recovery plans. Policy initiatives can involve investment in research and innovation, and (co-)development of digital tools in VET areas that may otherwise not be covered by technology, for example because of a small number of potential users (OECD, 2023[1]).

Initiatives to foster technology use in VET in Ukraine should be aligned with other VET reforms, as well as with the reconstruction of accessible and inclusive VET institutions. Moreover, this should happen in co-ordination with ongoing digital transformations in the broader education sector. Previous assessments of the strengths and weaknesses of the Ukrainian VET system highlighted ineffective management at all levels of VET and a lack of co-ordination in the sector as key challenges (AECOM, 2017[63]). While previous and ongoing reforms have tackled some of the governance challenges, limited integration of different parts of the education system remains a problem (ETF, 2020[64]; Leu-Severynenko, 2022[65]). Further action is needed on this front to make the most of the opportunities presented by technological innovation, for VET and for the education sector more broadly.

Co-ordination and collaboration should not only happen within the education sector. Digitalisation initiatives can also benefit from collaboration across relevant stakeholders outside the education system, which is often difficult to be initiated by one specific stakeholder. For instance, the use of AI in VET goes hand in hand with broader AI strategies and publicly-funded training programmes that proactively ensure the workforce is well-prepared to leverage the opportunities introduced by this technology, especially those targeting AI literacy and AI professionals (OECD, 2024[2]). Ukraine's National Strategy for the Development of AI, as well as its White Paper on AI Regulation, are critical in this respect.

Several examples highlight how strategic approaches help build an enabling environment for transforming VET through technology.

- The United Kingdom set out a strategy to provide guidance and support to education providers and the technology industry to boost the use of new technologies in education, for example, the 2019 *Realising the potential of technology in education: A strategy for education providers and the technology industry* (UK Department of Education, 2019[66]). As part of this process the government expects to support the development of the EdTech business sector in the UK, so it can deliver high-quality products that meet the needs of educators. In England (UK), an EdTech Innovation Fund was established by the Nesta Foundation and the Department for Education. The Fund supported EdTech organisations in England aiming to improve their products, carry out research about the impact that the use of their tools has, and grow their reach to more schools and colleges

in England. A first round of funding has already benefited more than a dozen EdTech companies (OECD, 2023[1]). The second round was the EdTech R&D Programme that benefited six EdTech companies (NESTA, 2021[67]).

- In Flanders (Belgium), the Flemish government launched the InnoVET project in 2019 to support VET providers and teachers to design, develop, use and test innovative technologies and pedagogies. InnoVET aligns with the Extended Reality (XR) Action Plan (2022-25), which is co-ordinated by the Knowledge Centre Digisprong, a Flemish support centre focused on helping schools integrate digital technologies into education. This support initiative aims to help schools develop IT visions, identify infrastructure challenges, provide professional development for teachers, and offer guidance on selecting digital tools and materials. To be eligible for InnoVET, VET providers must establish a local partnership for the co-financing, through which VET providers and teachers can secure expertise and equipment needed for implementation, accumulate knowledge from the start of the development phase and disseminate and share the knowledge across VET sector via learning platforms and events, with the possibility to upscale the use of technology in VET. InnoVET also produces free digital tools such as learning content websites, VR applications and guidelines for teachers on how to integrate technology in which context. Between 2019-2022, 29 projects were selected (OECD, 2023[1]). In the most recent cycle for the 2023-24 school year, six new projects were selected (Flemish Ministry of Education, 2024[68]).

- Estonia demonstrates that technological excellence in education requires a consistent strategy and policy support. After regaining independence in 1991 Estonia thoroughly reformed its education system using information technology (IT), by developing schools' local Internet connections, purchasing devices for teachers, supporting the creation of digital learning materials and advancement of teachers' digital skills. By 2001 all schools were equipped with computers and connected to the Internet and thousands of teachers took computer basic training course (OECD, 2023[1]). Now virtually all schools have digital literacy programmes, from basic programming to building little robots that students can control using tablets. Estonian researchers are looking into digital school textbooks that are adapted to the abilities of individual pupils (UNESCO, 2023[69]). Building on these achievements Estonia has kept innovating and developing its technological capacity in education. For example, the IT Academy Programme is a co-operation programme between the Estonian state, universities, VET schools and information and communication technology (ICT) companies. It aims to increase the quality of ICT-related education, develop research in the field and ensure the necessary labour resources. In VET, the IT Academy contributes to the quality of IT formal education in VET schools, so that VET in IT areas is seen as attractive and prepares well for high-quality employment and further education (OECD, 2023[1]).

- Establishing supporting and implementing bodies can facilitate and support technology adaptation in VET. For example, the Danish Government created two Knowledge Centres for Automation and Robot Technology to promote innovation in education and industry, supporting the work of VET schools making use of advanced technology. For instance, the centres make VR headsets and/or robots available to VET institutions (on loan), providing them with training materials and face-to-face technical support (OECD, 2023[1]).

- In Norway, grants are available for purchasing technologies, and these can only be spent on tools developed by suppliers in line with the Norwegian Education Act in order to both support and steer education institutions in the choice of digital tools. Evidence from Norway shows that setting up common standards and objectives for technological tools benefits both suppliers and the VET system. While stricter requirements may initially raise costs for suppliers, the common standards lower future development expenses by simplifying compliance with standardised regulations. This reduces adaptation costs and facilitates easier access to technology for schools. Standardisation also streamlines the acquisition and administration of digital tools (OECD, 2023[1]). At the same time, the Norwegian Digital Learning Arena (NDLA) was established as a joint project by all counties except Oslo to develop digital solutions for all their upper-secondary schools, including

VET programmes. It is a collaborative not-for profit organisation with the participating counties providing the funding and managing the scheme (see Box 5). Such policy initiatives shape and co-operate with the national digital strategy (OECD, 2024[70]).

Box 5. Norwegian Digital Learning Arena (NDLA)

In Norway, Norwegian Digital Learning Arena (NDLA) – the largest provider of open learning resources in Norway – was established as a joint project by all counties except Oslo to develop digital solutions for all their upper-secondary schools, including VET programmes.

NDLA offers freely available open digital learning resources for upper-secondary education and a range of learning resources with an open license that gives teachers, students and everyone else the right to use them. Open licenses provide the opportunity to share, use, create, modify and re-distribute learning resources. Among others, NDLA purchases goods and services on external markets through public procurement. The responsibility for the editorial work, organising, meta-tagging, and putting together the material in the respective subject areas lies with competent editing groups recruited from upper secondary schools in the counties. In 2021, NDLA bought goods and services from 98 suppliers. When the demand is not met by the supply, the editing groups will produce their own material.

Currently it provides learning resources in around 150 subject areas, as compared to 30 in 2009-10. In VET, NDLA has learning materials for all education programs in year 1, as well as in selected subjects in year 2 (in Norway the first two years of VET programmes are typically provided in schools and the last two in companies). The number of visits to the digital resources increased nine fold between 2010 and 2019 according to Google Analytics. NDLA is an important market player and there is some criticism that this situation can endanger competition in education and training technology market.

However, thanks to its position and available resources, NDLA can develop digital resources in 'niche' VET subjects. These subject areas may have been otherwise neglected by the technology suppliers as they are not profitable due to a limited number of potential consumers. To ensure the proposed digital material meets the quality standards, the content of each site is quality controlled by researchers and specialists in that field. NDLA also sets up collaborations with several pilot schools where students and teachers try out and evaluate the teaching aids before they are put into use.

Source: OECD (2023[1]), *Building Future-Ready Vocational Education and Training Systems*, https://doi.org/10.1787/28551a79-en.

Private sector partnerships

Integrating advanced technologies in VET involves significant upfront costs, including purchasing specialised equipment, software and ongoing maintenance expenses. Employers, especially those that benefit from technology use in VET, and EdTech companies can help offset these costs through direct funding, equipment donations, or subsidised licensing agreements. This collaboration not only reduces financial barriers for small or resource-poor VET providers but also enables broader adoption of state-of-the-art technologies to gain efficiency and effectiveness in VET, which are often out of reach for underfunded institutions (OECD, 2023[1]).

Moreover, the private sector can support capacity building by helping upskill VET teachers and trainers to use new technologies effectively. Employers, technology developers or relevant academic/research institutions can provide training sessions, workshops and on-the-job learning opportunities that familiarise VET teachers and trainers with the tools and systems employed in modern workplaces. This partnership ensures that VET teachers can deliver high-quality instruction that integrates technological advancements, fostering a more competent and adaptable workforce. In addition, sector-level partnerships can drive the

development, integration and use of technologies in VET – several sectors have already engaged in the development and dissemination of technologies for VET, for example, in the construction sector to create tailored training solutions that address unique industry requirements, bridging the gap between theoretical knowledge and practical skills (e.g. the International Conference on Construction Applications of Virtual Reality, since 2000). By investing in and supporting such initiatives, the private sector can ensure that VET programmes remain relevant and capable of preparing learners for the demands of tomorrow's workplaces.

Leu-Severynenko (2022[65]) highlighted undeveloped mechanisms of public-private partnership (PPP) and social dialogue in the VET sector, compounded by a loss of established partnerships with businesses due to the war, as a key obstacle for the development and modernisation of VET in Ukraine. Recent reforms, such as the establishment of specialised vocational centres, aim to promote collaboration with local business, focusing on high-demand sectors, which can help mobilise private sector support for overcoming financial constraints and ensure modern technologies reach both urban and rural VET institutions. In addition, leveraging international partnerships can also help secure funding and technical assistance for this transformation.

International examples can offer insights into effective employer engagement in this aspect.

- In Flanders (Belgium), the above-mentioned InnoVET project uses a co-financing model that promotes shared responsibility where 60% of the needed funding is financed by the government and 40% is financed by labour market actors such as EdTech companies, training employers and sectoral federations. To be eligible, VET providers must establish a local partnership for the co-financing. Technology applications developed through InnoVET projects are used not only among VET schools but also by sectoral bodies for training in Flanders (OECD, 2023[1]).

- The United States provides small enterprises with access to funding to produce education technology (EdTech) applications that could be later commercialised. The US Department for Education established the Small Business Innovation Research programme for this purpose. The fund promotes the use of EdTech to improve teaching practices and student learning outcomes (OECD, 2023[1]). The programme focuses on private sector commercialisation after product development to ensure sustainable dissemination to schools. While cost-sharing during the funding period is encouraged, it is not mandatory. This approach aims to motivate small businesses to invest in innovative technological solutions while fostering advancements in EdTech (U.S. Small Business Administration, 2023[71]).

- In the European Union, the Centre of Vocational Excellence (CoVE) aims to create ecosystems of innovation that align VET with the needs of the economy. CoVE fosters partnerships between VET providers, businesses, research institutions and other stakeholders, and serves as a hub for research, development and the implementation of advanced teaching and training methods, often leveraging cutting-edge technologies. The ALLVIEW project is an example of a CoVE in the wood and furniture industry that brings together 22 partners from 8 countries and focuses on enhancing innovation and technological integration in VET such as integration of immersive technologies into VET curricula (Allview, 2023[72]).

3.2. Technology and pedagogy should go together

The effective development and integration of technology in VET requires strong pedagogical approaches and digital skills among teaching professionals (OECD, 2021[6]). While technology offers efficient tools, the pedagogical approach makes a significant difference in learning outcomes even when using the same technology. For instance, structured and interactive approaches yield better results compared to unstructured, passive use of the same technology (OECD, 2021[6]). In particular, the limitations of technology and its use, such as reduced interpersonal interaction or motion sickness from prolonged use of virtual reality, highlight the need for intervention and guidance from teaching professionals. Vocational

teachers and in-company trainers play an important role in balancing traditional teaching with the use of technologies, carefully weighing their effectiveness, advantages and disadvantages compared to traditional methods. Solid pedagogical skills, alongside digital skills, are crucial for maximising the benefits of technology in VET while addressing its limitations. This calls for targeted training and support to build and further develop the capacity, knowledge and skills of VET teaching professionals to use innovative technologies effectively.

A lack of digital skills among VET teachers remains a significant barrier to effective technology use in VET, and variation in teachers' digital skills may thus result in unequal access to technologies by students (OECD, 2023[1]). Evidence from OECD countries shows that many VET teachers do not use digital technologies for teaching or lack confidence in doing so. For example, one in four VET teachers using the European Commission's SELFIE tool (described below) in OECD countries reported limited confidence in applying digital technology in classroom teaching or providing student feedback. This challenge is more pronounced among older VET teachers: while 82% of VET teachers in their 30s feel confident using digital technology to prepare lessons, this confidence drops to half among teachers over 60 (OECD, 2021[6]). Providing professional development opportunities is essential to ensuring VET professionals, especially older ones, are supported in this transition. By building digital and pedagogical skills, VET teachers and trainers can more effectively integrate innovative technologies into their programmes (OECD, 2022[5]).

The war has accelerated the need for digitalisation in VET in Ukraine, as many institutions have had to shift to remote or hybrid learning. However, teacher preparedness remains a significant challenge. Ukraine should thus prioritise developing and improving VET teacher training programmes, focusing on pedagogical and digital skills to effectively integrate technology in VET teaching. The Profosvita platform described in Section 1 already includes various training programmes for VET teachers, and could be further expanded to cover more digital-related training options, as well as assessment tools to identify digital skills gaps. The Conceptual and Reference Framework for Digital Competence of Pedagogical and Academic Staff (UA DigCompEdu framework[1]) can serve as a baseline for identifying and developing relevant training materials.

Moreover, it is crucial to involve VET teachers as well as employers and industry experts in designing, developing, and integrating new applications and solutions. This ensures that learning materials are relevant and user-friendly for the VET context and can effectively support teachers. Several countries encourage such collaboration by fostering partnerships between the VET sector, industry, EdTech companies, and research institutions (OECD, 2023[1]). Additionally, providing support to simplify technology adoption and use for teachers, along with scalable, shareable tools that enable easy modification of content to reflect changing needs, can empower teachers, promote the seamless, sustainable integration of technology in VET, drive innovation and improve the use of technology in VET.

OECD experience can inform Ukraine about challenges and policy options in this regard, for example:

- In Switzerland, in the framework of the BeLEARN initiative, the Swiss Federal University for Vocational Education and Training (SFUVET) is conducting a project "Mapping of Teachers' AI-related Competences in Vocational Education" throughout the year 2025 in collaboration with the Swiss Distance University of Applied Sciences. This project aims to assess the status quo regarding AI competences among VET teachers using an adapted version of a previously established AI-specific questionnaire, which was used only in general education. The project also aims to validate the adapted self-assessment instrument itself and create a framework for a counselling model involving self-reflective prompting questions, which are informed by competence profiles showing individual strengths and weaknesses based on the participants' scores, resulting in individualised feedback (SFUVET, 2024[73]). In addition, in 2018, SFUVET designed Digi-Check, an assessment tool to help VET institutions evaluate their digital transformation needs. The tool focuses on assessing the digital skills of teachers and learners, identifying areas for improvement, and defining measures for enhancing teaching practices with digital media. The assessment is

conducted through workshops and coaching, with the goal of fostering effective digital transformation in VET (SFUVET, 2025[74]).

- In England (the United Kingdom), the Enhance Digital Teaching Platform supports teachers to use technology and innovate pedagogical approaches in the VET sector. Developed by the Education and Training Foundation in 2019 and funded by the Department for Education, the platform provides training modules that are mapped to the Digital Teaching Professional Framework. This Framework is a competence framework for teaching and training practitioners in the further education and training sector, designed to focus on the benefits of good pedagogy supported by technology to enhance learning and promote professional standards for supporting learning through technology. It sets out three stages of competence, which are adapted from the European Framework for Digital Competence of Educators: (i) Exploring: practitioners assimilate new information and develop basic digital practices; (ii) Adopting: practitioners apply their digital practices and expand them further; and (iii) Leading: practitioners pass on their knowledge, critique existing practice and develop new practices. The Framework is accompanied by free, online, bite-size training modules with certification. Used alongside the Jisc Discovery Tool, a self-assessment tool that teaching staff can use to assess their digital capabilities, it enables practitioners to identify their training needs in order to help develop their teaching practice (OECD, 2021[6]).

- Flanders (Belgium) upgrade technological skills of VET teachers through collaboration. The above-mentioned InnoVET aims to support teachers with the design, choice and use of technologies in classrooms. To be eligible for financial support projects should include professional development for teachers. Materials and lessons learnt are shared across the VET sector. VET schools and teachers thus have the opportunity to share their experience using digital technologies (OECD, 2023[1]).

- Denmark established Knowledge Centres to support VET institutions and VET teachers and trainers with the use of technology. The Knowledge Centre for IT in Teaching promotes the use of digital technology in VET, supporting pedagogical innovation across all subjects. The centre provides professional development opportunities on IT issues for teachers in VET. Their PD courses include both theoretical and practical elements to support teaching and learning. The centre has also established a network of pedagogical staff and a network of leaders to facilitate the exchange of ideas and share their practical and technical knowledge, creating new solutions to common challenges (OECD, 2023[1]; OECD, 2021[6]).

- Across the EU, the European Commission's SELFIE (Self-reflection on Effective Learning by Fostering the Use of Innovative Educational Technologies)[2] tool–a free online tool designed to help education and learning providers in Europe and beyond embed digital technology into teaching, learning and assessment–can be used to gather the views of students, teachers, in-company trainers and school leaders on how technology is used in their school. Their inputs can be used by schools to formulate an action plan and set priorities to implement changes to support teaching, learning and student assessment. The results from such an assessment can be used to develop an innovation plan for VET systems (OECD, 2022[5]).

- In addition, implemented in the EU under Erasmus+, the AI4T project aims to provide an AI training pathway for teachers in the areas of math, science, and modern English language. The project benefits teachers by providing access to professional development training and opportunities to participate in an e-community focused on AI in education. It also allows them to develop and share their best practices. The project is beneficial to researchers and policymakers as well. The evaluation phase is approaching completion, and policy recommendations will be provided (European Commission, 2023[75]).

3.3. Ensuring the responsible, ethical and secure use of technology and the data generated by the use of technology is key to transforming VET

While the integration of innovative technologies such as AI, immersive technologies and big data analytics offers opportunities to transform training, learning experiences and VET systems, it also comes with risks (OECD, 2023[3]). For example, the digital divide remains a significant barrier and may lead to unequal access to high-quality digital infrastructure and devices, which can exacerbate disparities in learning outcomes, particularly for marginalised groups (OECD, 2023[62]; OECD, 2023[3]). Digital literacy is one of the barriers, which will be particularly important to monitor and tackle to ensure that a more digital VET system remains accessible to all (especially older learners). A 2023 survey of digital skills among the Ukrainian adult population showed that 7.2% of adults have no digital skills, and an additional 33.2% have low digital skills. 38% of adult have above basic digital skills, and this share has been on the rise in recent years (up from 25.5% in 2019) (Ministry of Digital Transformation of Ukraine, 2023[76]). While the share of adults without any digital skills and with low digital skills is declining steadily (from 15.1% and 37.9%, respectively, in 2019), there is still a considerable share of adults who are risk being left behind as the Ukrainian society and economy becomes more and more digital. Weak digital skills are much more commonly found among older adults in Ukraine. As such, the digitalisation of VET should go hand in hand with efforts to reach out to individuals who have low access to digital resources and support their adoption of digital learning -including through basic digital skills training. Addressing regional disparities in digital infrastructure – particularly in war-affected areas – is also crucial for equitable access to digital learning opportunities.

In addition to the digital divide, there are also concerns about data privacy and security in a digital era, including in a more digital education system, as the collection and analysis of learner data by AI and big data systems could lead to misuse or breaches. For Ukraine, these concerns are particularly urgent, given the increasing reliance on digital solutions in education and training, including VET, due to the current need for remote and hybrid learning. Moreover, the volume and scope of cyberattacks against Ukraine have been very high since the start of the large-scale invasion (European Parliament, 2023[77]).

Therefore, leveraging these technologies and data effectively demands addressing critical concerns around privacy, data protection, and responsible and ethical use. Several countries already started considering the needs and establishing frameworks and guidelines necessary for the responsible and ethical handling and secure use of technology and data. For example, OECD AI Principles and G20 AI Principles provide guidelines for responsible stewardship of trustworthy AI, which emphasise: (i) inclusive growth, sustainable development and well-being; (ii) human-centred values and fairness; (iii) transparency, explainability and accountability; and (iv) robustness, security and safety of AI systems (Vincent-Lancrin and van der Vlies, 2020[41]; OECD, 2024[78]). These principles lead the way for VET systems and institutions to maintain trust, ensure quality and equity, and foster further innovation.

Addressing the human-centred values in VET systems is particularly critical (Vincent-Lancrin and van der Vlies, 2020[41]). For example, diagnosis and predictions made by AI, adaptive learning data and early warning systems need human intervention to make the final judgment and decision (OECD, 2023[3]). While private sector partnerships can facilitate access to advanced technology, it is essential to establish collaborative frameworks that align with shared ethical standards, ensuring equitable access, data privacy, and responsible use. This approach balances innovation with the need to foster trust and safety in digital tools. In addition, VET teachers, leaders and programme designers need targeted training to integrate AI, data-driven and other digital tools responsibly without compromising ethical standards or learners' privacy while minimising potential biases and misuses. Moreover, robust IT and data protection infrastructure and comprehensive standards are needed to navigate these barriers and correct systemic errors. By fostering a culture of ethical responsibility, countries can also maximise the benefits of digital transformation while safeguarding equity and inclusion (OECD, 2023[1]; OECD, 2023[3]; OECD, 2024[79]). Moreover, a learner-centred approach for technology use in VET should also take into account that the reliance on technology

in VET systems may have adverse effects on health (e.g. VR sickness or other discomforts) (Kim et al., 2020[37]; Cedefop/OECD, 2023[18]), if not properly addressed, carefully designed and monitored, or pedagogically balanced.

Policy interventions and monitoring mechanisms are thus indispensable to ensure the secure application of technology and data. Comprehensive indicators are needed to monitor and evaluate the effectiveness, quality, and outcomes of technology use in VET. In particular, when using digital tools based on advanced technology that are high stakes for students, teachers, or educational establishments, such as digital forms of evaluation, assessment and certification, educational jurisdictions should be transparent about the objectives and processes by which algorithms reach their recommendations as well as limitations. The uses of high-stakes technology solutions must be discussed and negotiated with all relevant stakeholders (Vincent-Lancrin and van der Vlies, 2020[41]).

Strengthening cybersecurity and data protection frameworks should be a priority in Ukraine, especially for platforms such as Profosvita and Mriia (described in Section 1), ensuring careful and safe implementation of technologies. Establishing national guidelines and implementation measures can help address these challenges, aligning with international best practices. Building institutional capacity and providing targeted training for VET administrators and teachers can also help ensure secure, responsible and transparent technology integration. The Profosvita platform could host training for VET teachers and administrators on this matter, alongside materials to help them assess and mitigate risks. Teachers who are conscious of the risks can also pass on these attitudes and skills to their VET learners, contributing to the overall cybersecurity skills of the Ukrainian population.

International examples highlight the importance of proactive planning and ethical foresight and frameworks in using technology and data as well as the importance of national-level co-ordination in creating secure, accessible and transparent digital ecosystems for VET institutions.

- Flanders (Belgium) has developed basic requirements to use AI responsibly, including focusing on using AI as a learning tool based on shared values and continuous evaluation and applying moral values and ethical and legal frameworks. Flanders is also developing an Action Plan focused on investments in teacher training, gathering data on how AI is used for teaching/learning and implementation of responsible AI use in education to generate good practices (Flemish Department of Education and Training, 2024[80]).

- In Croatia, the Agency for Vocational Education and Training and Adult Education has signed a Partnership Agreement to collaborate with the Croatian Academic and Research Network (CARNET) on the preparation and implementation of the BrAIn project (Application of Digital Technologies Based on Artificial Intelligence in Education). This project aims to foster a comprehensive understanding of AI among students, preparing them for future challenges and opportunities in a digitally-driven world, while ensuring that ethical considerations remain at the forefront of technological integration in education. The project also includes the development of digital educational content, training for educational staff, and research on the impact of digital technologies on students. A Committee for the Ethical Application of Digital Technologies and AI in Education has been established to monitor the integration of AI into the curriculum, ensuring that ethical considerations are addressed throughout the project's implementation. This committee collaborates with entities such as the Laboratory for Ethical Aspects of Advanced Digital Technology at the University of Rijeka's Center for Artificial Intelligence and Cybersecurity, which focuses on the ethical implications of AI and advanced digital technologies. Additionally, the Croatian Artificial Intelligence Association (CroAI) is involved in the BrAIn project, providing advisory support on curriculum development (Croatian Agency for Vocational Education and Training and Adult Education, 2024[81]).

- Norway uses Feide, a national, centralised identity management solution for the education sector, providing secure authentication and authorisation for students, educators, and administrators. It

offers a single sign-on system that streamlines access to digital services, integrates with learning tools like LMS platforms, and adheres to the General Data Protection Regulation for robust data privacy. In addition, Norway's data protection authority monitors and evaluates the use of data in the education sector including VET (see Box 6 for more details).

Box 6. Norway's data protection mechanisms in VET

Norway uses Felles Elektronisk IDEntitet (FEIDE), a common electronic identity system, for safe online identification in the educational sector. It serves as an identity management service that allows for simple identification and access to various IT services through a unified login system. If the digital learning resource requires login, it must be able to authenticate users through FEIDE. FEIDE provides a centralised method for storing user information and facilitating authentication across multiple educational platforms and services.

While there are always risks involved in the use and storage of data, a robust monitoring and evaluation mechanism can identify data breaches and continuously improve the system. For example, in Norway, the municipality and county authorities are responsible for complying with the data protection regulations in schools for which they are responsible. The Norwegian Data Protection Authority (Datatilsynet) has established requirements for school owners who are going to use learning platforms, including carrying out a Data Protection Impact Assessment (DPIA) (Udir, 2024[82]). In recent years, Datatilsynet has addressed several data protection issues within the education sector and fined several municipalities for failing to conduct a Data Protection Impact Assessment (DPIA) before implementing a training app in schools, which allowed unauthorised access to students' personal data, tracked students' locations and processed special categories of personal data without prior risk assessment (European Data Protection Board, 2019[83]). These cases underscore the importance of robust security measures and thorough testing before deploying digital applications in education and highlights the necessity of comprehensive risk assessments and stringent security protocols such as DPIAs when introducing and integrating new digital tools in educational settings.

Furthermore, the Norwegian Ministry of Education and Research appointed an Expert Group in 2021 to assess digital learning analytics in primary and secondary education and training, tertiary vocational education and higher education. The Group's recommendations in 2023 include:

- Clarifying the legal basis for learning analytics in primary and secondary education and training, higher education and tertiary vocational education.
- Developing a data protection code of conduct to strengthen pupils' and students' data protection and facilitate good data protection practices.
- Establishing frameworks for good learning analytics to strengthen the free choice of pupils and teachers and to provide a better basis for pedagogical decisions.
- Developing broad guidelines for good and justifiable learning analytics in higher education and tertiary vocational education that promote student learning and increase the quality of education.

Source: Norvegian Center for ICT in Education (2012[84]), Quality Criteria for Digital Learning Resources, The Directorate for Education and Training, www.udir.no/globalassets/filer/tall-og-forskning/rapporter/2012/quality_criteria_dlr-eng.pdf; European Data Protection Board (2019[83]), The Norwegian Data Protection Authority imposes a fine on the Municipality of Oslo, the Education Agency, www.edpb.europa.eu/news/national-news/2019/norwegian-data-protection-authority-imposes-fine-municipality-oslo_en; Norwegian Ministry of Education and Research 2023 "Learning: Lost in the Shuffle? Use of pupil and student data to enhance learning", Official Norwegian Reports NOU 2023: 19, www.regjeringen.no/en/dokumenter/nou-2023-19/id2982722/?ch=5.

References

Abrahams, M. (2018), *Patron Think Piece - Aptem: Smart machines can transform apprenticeships,*, https://www.aelp.org.uk/news/news/think-pieces/patron-think-piece-aptem-smart-machines-can-transform-apprenticeships/. [60]

Advance CTE (2021), *Dallas Virtual Internship Toolkit*, https://careertech.org/wp-content/uploads/2023/01/Dallas_Virtual_Internship_Toolkit.pdf. [42]

AECOM (2017), *Formulation of EU Support to Reforms in Vocational Education and Training (VET) in Ukraine. Final*. [63]

Allview (2023), *D3.3.1. Integration of VR and MR as complementary Tools in the Curriculum*, https://allview.eu//wp-content/uploads/2023/06/ALLVIEW_Report_D3.3.1_Integration-of-VR-and-MR-as-complementary-tools-in-the-curriculum_-1.pdf. [72]

Amenduni, F. and A. Cattaneo (2022), *The digital transformation of apprenticeships: Emerging opportunities and barriers*, ILO, https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@ed_emp/@ifp_skills/documents/publication/wcms_861712.pdf. [16]

Angel-Urdinola, D., C. Castillo-Castro and A. Hoyos (2021), *Meta-Analysis Assessing the Effects of Virtual Reality Training on Student Learning and Skills Development*, World Bank, https://openknowledge.worldbank.org/server/api/core/bitstreams/4d6047ed-c6fa-5bd1-ba2a-f876ec62ded8/content. [32]

aptem (2023), *Finding the best apprenticeship delivery platform*, https://www.aptem.co.uk/aptem-news/finding-the-best-apprenticeship-delivery-platform/. [25]

Beh, H. et al. (2021), "Developing engineering students' capabilities through game-based virtual reality technology for building utility inspection", *Engineering, Construction and Architectural Management*, Vol. 29/7, pp. 2854-2877, https://doi.org/10.1108/ecam-02-2021-0174. [36]

Broecke, S. (2023), "Artificial intelligence and labour market matching", *OECD Social, Employment and Migration Working Papers*, No. 284, OECD Publishing, Paris, https://doi.org/10.1787/2b440821-en. [22]

Cedefop (2022), *The future of vocational education and training in Europe. Volume 3, The influence of assessments on vocational learning*, Publications Office of the European Union, https://data.europa.eu/doi/10.2801/067378. [46]

Cedefop/OECD (2023), *Apprenticeships and the Digital Transition: Modernising Apprenticeships to Meet Digital Skill Needs*, Publications Office of the European Union, Luxembourg, https://www.cedefop.europa.eu/files/3096_en.pdf. [18]

Cedefop; European Commission; ETF; ILO; OECD; UNESCO (2021), *Perspectives on policy and practice: tapping into the potential of big data for skills policy*, Publications Office, Luxembourg, https://data.europa.eu/doi/10.2801/25160. [50]

Croatian Agency for Vocational Education and Training and Adult Education (2024), *Application of Digital Technologies Based on Artificial Intelligence in Education – BrAIn*, https://www.asoo.hr/en/projects-and-cooperation/esfplus-projects/support-for-the-application-of-digital-technologies-in-education-brain/. [81]

Dahlke, J. and D. Putka (2021), *Streamlining the Identification of Emerging Tasks in the O*NET System Using Natural Language Processing (NLP): Technical Summary*, https://www.onetcenter.org/reports/EmergingTasksNLP.html. [52]

Dillenbourg, P. et al. (eds.) (2022), *Educational Technologies for Vocational Training, Experiences as Digital Clay*, https://www.sfuvet.swiss/sites/default/files/2022-10/01-dualt%20book_Educational%20Technologies%20. [29]

DTT (n.d.), *OntdekMBO: Playfully looking for suitbale education*, https://www.d-tt.nl/en/apps/mbo-stad. [28]

EBA (2024), *Mriia launched*, https://eba.com.ua/en/zapustyly-mriyu/. [15]

Education Scotland (2021), *Emerging technologies, emerging practices in education*, https://education.gov.scot/resources/emerging-technologies-emerging-practices-in-education/. [21]

ENSMV (2025), *Campus Digital des Metiers de la Viande*, https://ensmv.com/wp-content/uploads/2025/01/FinalCampusdigital.pdf. [40]

EPFL (2023), *REALTO: The online learning platform for integrated vocational education*, https://www.epfl.ch/labs/chili/dualt/current-projects/realto/. [47]

ETF (2020), *Policies for Human Capital Development - Ukraine*. [64]

European Commission (2023), *Minutes: 3rd Peer Learning Activity (PLA) of the EEA Strategic Framework Working Group on Digital Education: Learning, Teaching and Assessment (DELTA)*, https://ec.europa.eu/transparency/expert-groups-register/core/api/front/document/97157/download. [75]

European Commission (2022), *A better way to verify educational and employment credentials*, https://cordis.europa.eu/article/id/430222-a-better-way-to-verify-educational-and-employment-credentials. [48]

European Commission (2022), *Digital Skills for a Sustainable Future*, Erasmus+ Programme, https://erasmus-plus.ec.europa.eu/projects/search/details/2022-2-SI01-KA210-VET-000095861. [44]

European Data Protection Board (2019), *The Norwegian Data Protection Authority imposes a fine on the Municipality of Oslo, the Education Agency*, https://www.edpb.europa.eu/news/national-news/2019/norwegian-data-protection-authority-imposes-fine-municipality-oslo_en. [83]

European Parliament (2023), *The role of cyber in the Russian war against Ukraine: Its impact and the consequences for the future of armed conflict*. [77]

Flemish Department of Education and Training (2024), *BE presentation ACVTDGVT webinar AI in VET*. [80]

Flemish Ministry of Education (2024), *InnoVET projects school year 2023 - 2024*, https://onderwijs.vlaanderen.be/onderwijspersoneel/van-basis-tot-volwassenenonderwijs/lespraktijk/innovet/de-projecten/innovet-projecten-schooljaar-2023-2024. [68]

Guedes, H. et al. (2019), "Virtual reality simulator versus box-trainer to teach minimally invasive procedures: A meta-analysis", *International Journal of Surgery*, Vol. 61, pp. 60-68, https://doi.org/10.1016/j.ijsu.2018.12.001. [33]

ILO (2022), *"Virtual" is now a TVET training reality in North Macedonia*, https://www.ilo.org/budapest/whats-new/WCMS_840380/lang--en/index.htm. [39]

ILO (2022), *Strengthening digital TVET in Ukraine*, https://www.ilo.org/skills/Whatsnew/WCMS_836777/lang--en/index.htm. [13]

Interplay (n.d.), *Build Skills Faster! Interplay website*, https://www.interplaylearning.com/. [38]

IT Ukraine Association (2024), *The Ministry of Digital Transformation presented the Super App Mriya to the IT Ukraine Association and regional clusters*, https://itukraine.org.ua/en/the-ministry-of-digital-transformation-presented-the-super-app-mriya-to-the-it-ukr. [14]

Joosten, T. et al. (2020), *Digital Learning Innovation Trends*, https://files.eric.ed.gov/fulltext/ED603277.pdf. [20]

Kim, K. et al. (2020), "Using immersive virtual reality to support designing skills in vocational education", *British Journal of Educational Technology*, Vol. 51/6, pp. 2199-2213, https://doi.org/10.1111/bjet.13026. [37]

Kirillova, Y., V. Znoviak and A. Kazan (2023), *Needs and obstacles of veterans in employment*, Ukrainian Veterans Foundation, https://veteranfund.com.ua/wp-content/uploads/2023/11/Veteran_employment.pdf. [12]

Kutsekoda (n.d.), *Kutsekoda*, https://oska.kutsekoda.ee/en/oska-management-methodology/oska-methodology/ (accessed on 7 September 2024). [55]

Leu-Severynenko, S. (2022), *A Short Overview on Vocational Education and Training in Ukraine: Current Status, Challenges and Reform Intentions*, BIBB. [65]

Lewis, P. and J. Morris (2024), *Supplementing the O*NET Sources of Additional Information: A Preliminary Exploration of the Use of ChatGPT*, https://www.onetcenter.org/reports/SAI_GPT.html. [53]

Ministry of Digital Transformation of Ukraine (2023), *Digital Literacy Research*. [76]

Ministry of Education and Science of Ukraine (2024), "Про затвердження Дорожньої карти розвитку професійної (професійно-технічної) освіти для осіб з інвалідністю та інших маломобільних груп населення на період до 2030 року", https://zakon.rada.gov.ua/rada/show/v0717729-24#Text. [9]

Ministry of Education and Science of Ukraine (2023), *Rebuilding the country requires specialists in working professions [Відбудова країни потребує фахівців робітничих професій]*, https://www.kmu.gov.ua/news/vidbudova-krainy-potrebuie-fakhivtsiv-robitnychykh-profesii-dlia-ikhnoho-navchannia-u-2024-rotsi-transformuiut-100-maisteren-zakladiv-proftekhosvity. [8]

Multiverse (2024), *Multiverse website*, https://www.multiverse.io/en-US/. [26]

NESTA (2021), *Supporting disadvantaged students to overcome barriers to effective remote learning*, https://www.nesta.org.uk/project-updates/supporting-disadvantaged-students-overcome-barriers-remote-learning/. [67]

Norwegian Center for ICT in Education (2012), *Quality Criteria for Digital Learning Resources*, Norwegian Directorate for Education and Training (Udir), https://www.udir.no/globalassets/filer/tall-og-forskning/rapporter/2012/quality_criteria_dlr-eng.pdf. [84]

Odarchenko, K. (2024), *Will War Veterans Dominate Ukraine's Post-War Leadership?*, https://cepa.org/article/will-war-veterans-dominate-ukraines-post-war-leadership/. [11]

OECD (2024), *Bridging Talent Shortages in Tech: Skills-first Hiring, Micro-credentials and Inclusive Outreach*, Getting Skills Right, OECD Publishing, Paris, https://doi.org/10.1787/f35da44f-en. [61]

OECD (2024), *Education Policy Outlook 2024: Reshaping Teaching into a Thriving Profession from ABCs to AI*, OECD Publishing, Paris, https://doi.org/10.1787/dd5140e4-en. [59]

OECD (2024), *Observatory on Digital technologies in Career guidance for Youth (ODiCY)*, OECD, https://www.oecd.org/en/about/programmes/odicy.html. [23]

OECD (2024), *OECD Digital Economy Outlook 2024 (Volume 1): Embracing the Technology Frontier*, OECD Publishing, Paris, https://doi.org/10.1787/a1689dc5-en. [79]

OECD (2024), *Recommendation of the Council on Artificial Intelligence*, OECD, Paris, https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0449. [78]

OECD (2024), *Shaping Norway's Digital Future*, OECD Publishing, Paris, https://doi.org/10.1787/d3af799c-en. [70]

OECD (2024), *Training Supply for the Green and AI Transitions: Equipping Workers with the Right Skills*, OECD Publishing, Paris, https://doi.org/10.1787/7600d16d-en. [2]

OECD (2023), *Building Future-Ready Vocational Education and Training Systems*, OECD Reviews of Vocational Education and Training, OECD Publishing, Paris, https://doi.org/10.1787/28551a79-en. [1]

OECD (2023), *CiCi, the 24/7 careers chatbot*, https://www.oecd.org/en/publications/observatory-on-digital-technologies-in-career-guidance-for-youth-odicy_e098122e-en/cici-the-24-7-careers-chatbot_9ccfd77d-en.html. [24]

OECD (2023), *OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem*, OECD Publishing, Paris, https://doi.org/10.1787/c74f03de-en. [3]

OECD (2023), *OECD Employment Outlook 2023: Artificial Intelligence and the Labour Market*, OECD Publishing, Paris, https://doi.org/10.1787/08785bba-en. [4]

OECD (2023), *OECD Ukraine Country Programme*, OECD, Paris, https://www.oecd.org/en/about/programmes/oecd-ukraine-country-programme.html. [7]

OECD (2023), *Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency*, OECD Publishing, Paris, https://doi.org/10.1787/bac4dc9f-en. [62]

OECD (2022), *Strengthening Apprenticeship in Scotland, United Kingdom*, OECD Reviews of Vocational Education and Training, OECD Publishing, Paris, https://doi.org/10.1787/2db395dd-en. [5]

OECD (2021), *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en. [17]

OECD (2021), *OECD Skills Strategy Lithuania: Assessment and Recommendations*, OECD Skills Studies, OECD Publishing, Paris, https://doi.org/10.1787/14deb088-en. [58]

OECD (2021), *Teachers and Leaders in Vocational Education and Training*, OECD Reviews of Vocational Education and Training, OECD Publishing, Paris, https://doi.org/10.1787/59d4fbb1-en. [6]

OECD (2020), *Strengthening the Governance of Skills Systems: Lessons from Six OECD Countries*, OECD Skills Studies, OECD Publishing, Paris, https://doi.org/10.1787/3a4bb6ea-en. [56]

OS Analytics (n.d.), *Open Syllabus Analytics Webisite*, https://analytics.opensyllabus.org/. [54]

Piromchai, P. et al. (2015), "Virtual reality training for improving the skills needed for performing surgery of the ear, nose or throat", *Cochrane Database of Systematic Reviews*, Vol. 2015/11, https://doi.org/10.1002/14651858.cd010198.pub2. [34]

Putka, D., J. Dahlke and M. Burke (2023), *Using Machine Learning to Develop Occupational Interest Profiles and High-Point Codes for the O*NET System*, https://www.onetcenter.org/reports/ML_OIPs.html. [51]

Ravichandran, R. and J. Mahapatra (2023), "Virtual Reality in Vocational Education and Training: Challenges and Possibilities", *Journal of Digital Learning and Education*, Vol. 3/1, pp. 25-31, https://doi.org/10.52562/jdle.v3i1.602. [31]

SFUVET (2025), *Let the Digi-Check take your institution or professional organisation into the digital future*, https://www.sfuvet.swiss/digi-check. [74]

SFUVET (2024), *Two new BeLEARN projects on educational technologies at SFUVET*, https://www.sfuvet.swiss/news/two-new-belearn-projects-educational-technologies-sfuvet. [73]

Southgate, E. et al. (2018), *Artificial intelligence and emerging technologies (virtual, augmented and mixed reality) in schools: A research report.*, Newcastle: University of Newcastle, Australia., https://researchoutput.csu.edu.au/ws/portalfiles/portal/204781210/204218563_published_report.pdf. [19]

Studinfo (n.d.), *Studyinfo - Explore lifelong learning in Finland*, https://opintopolku.fi/. [27]

Sukardi, H., U. Risfendra and Y. Doni Tri Putra (2024), "Effectiveness of Robotic Technology in Vocational Education: A Meta-Analysis", *International Journal of Information and Education Technology, Vol. 14, No. 4, 2024*, https://doi.org/10.18178/ijiet.2024.14.4.2073. [35]

Tang, Y. et al. (2022), "A systematic review of immersive technology applications for medical practice and education - Trends, application areas, recipients, teaching contents, evaluation methods, and performance", *Educational Research Review*, Vol. 35, p. 100429, https://doi.org/10.1016/j.edurev.2021.100429. [30]

TEM (n.d.), *Labour barometer*, https://tem.fi/tyovoimabarometri (accessed on 7 September 2024). [57]

Triumf (2024), *Discover Triumfland for wellbeing*, https://www.triumf.health/news. [45]

U.S. Small Business Administration (2023), *Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Program*, https://www.sbir.gov/sites/default/files/2024-07/SBA%20SBIR_STTR_POLICY_DIRECTIVE_May2023.pdf. [71]

Udir (2024), *Kindergarten and school owner's privacy responsibility*, Udir, https://www.udir.no/regelverk-og-tilsyn/personvern-for-barnehage-og-skole/barnehage--og-skoleeiers-ansvar/. [82]

UK Department of Education (2019), *Realising the potential of technology in education: A strategy for education providers and the technology industry*, https://assets.publishing.service.gov.uk/media/5ca360bee5274a77d479facc/DfE-Education_Technology_Strategy.pdf. [66]

Ukrainian Veterans Fund (2022), *Portrait of a veteran in Russian-Ukrainian war 2014-2022*, https://veteranfund.com.ua/en/analitik/portrait-of-a-veteran-in-russian-ukrainian-war/#:~:text=In%20terms%20of%20percentage%2C%20the,61%2B%20years%20%E2%80%93%201.5%2. [10]

UNESCO (2023), *Estonia, an early convert to digital technology*, https://courier.unesco.org/en/articles/estonia-early-convert-digital-technology. [69]

Vametric (n.d.), *What is VALID-8?*, https://vametric.com/. [49]

Vincent-Lancrin, S. and R. van der Vlies (2020), "Trustworthy artificial intelligence (AI) in education: Promises and challenges", *OECD Education Working Papers*, No. 218, OECD Publishing, Paris, https://doi.org/10.1787/a6c90fa9-en. [41]

WEAVE (2024), *Web accessibility through VET: WEAVE Accessible Web Design VET Toolkit,*, https://joistpark.eu/wp-content/uploads/2024/07/WEAVE-D2_Accessible-Web-Design-VET-Toolkit_EN.pdf. [43]

Notes

[1] The framework was fully developed by the dComFra consortium. It has been agreed with all interested public authorities, representatives of professional communities and business. After making minor and specific for the Ukrainian educational environment corrections, it was published by the Ministry of Digital Transformation of Ukraine in 2021, see https://osvita.diia.gov.ua/uploads/0/2900-2629_frame_pedagogical.pdf.

[2] It was developed based on the European Commission Framework for Digitally-Competent Educational Organisations (DigCompOrg). The tool was developed with a team of experts from schools, education ministries and research institutes across Europe.