The Future of Work and Lifelong Learning

▶ Promoting apprenticeships to meet the skills needs of the digital and knowledge economy

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▶ Foreword

New technologies, demographic shifts, climate change, globalization and more recently the crisis such as global health pandemic are causing major disruptions to the world of work. Against this backdrop, it becomes ever more important to build an agile workforce capable of navigating the fast-changing labour market through appropriate and timely skilling, reskilling and upskilling. The use of apprenticeship models or dual training systems can be an effective solution in the context of the future of work, as it bridges the gap between education and training system and the world of work.

Although apprenticeship is a centuries-old system which enable young persons to acquire skills related to specific occupations, questions are increasingly being raised about its relevance for reskilling and upskilling in the context of the future of work and lifelong learning.

The ILO has therefore launched a research project – *Apprenticeship Development for Universal Lifelong Learning and Training (ADULT)*– which aims to generate new ideas and policy options to modernise apprenticeship systems. The project is funded by the Government of Flanders. The research aims to explore how apprenticeship systems are being modernised and transformed to promote and enable lifelong learning and decent work for youth, adults, and older workers (both employed and unemployed). The research also covers other forms of work-based learning options for students in VET institutes.

The research paper titled *"Promoting apprenticeships to meet the skills needs of the digital and knowledge economy"* has been produced by the ILO as part of the ADULT project. It explores the impact of the digital technologies on jobs.

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▶ Acknowledgments

▶ Contents

▶ List of boxes

▶ List of figures

▶ List of acronyms

AI	Artificial Intelligence
CRM	Customer Relationship Management
DESI	Digital Economy and Society Index
DigComp	European Digital Competence Framework for Citizens
GDP	Gross Domestic Product
GTOs	Group Training Organizations
ICT	Information and Communications Technology
ILO	International Labour Organization
IoT	Internet of Things
IT	Information Technology
ITE	Institute of Technical Education
NASSCOM	National Association of Software and Service Companies
NSDC	National Skills Development Corporation, India
OECD	Organisation for Economic Co-operation and Development
SMEs	Small and Medium Enterprises
SSCs	Sector Skills Councils
TVET	Technical and Vocational Education and Training

Executive Summary

▶ Introduction

This paper explores how apprenticeship systems need to change in order to prepare people for good quality jobs in rapidly changing digital and knowledge-based economies. It is structured in five chapters. The introduction explores various definitions and sets the scene. The second chapter explores the impact of digitalization on jobs. The third looks at the skills needs of digital and knowledge-based economies, highlighting the challenges for apprenticeship systems. The fourth draws on evidence from four country case studies and other sources to explore good practices and issues in overcoming these challenges. The report closes with recommendations designed to help countries consider different ways forward in modernizing apprenticeships to meet the challenge of digitalization.

The introductory section begins by defining the terms used and then explores the differences between knowledge-based and digital economies. It argues that the knowledge economy recognizes the fundamental importance of intellectual capital derived from effective skills and education systems, including apprenticeships. Digitalization, or the growth of the digital economy, highlights the speed and nature of the profound change and disruption that societies must prepare for. It also underscores the need for our education and skills systems to become sufficiently agile in order to cope with the speed of this change.

▶ The impact of the digital and knowledge economy on jobs

The report identifies eight main issues arising from the transformation to digital and knowledge-based economies which impact jobs:

1. Digitalization and the shift to a knowledge-based economy inevitably influences jobs and skills, but the shift is not as all-encompassing as might have been predicted.

2. Digitalization plays out differentially in different economies.

3. Digitalization is only one factor affecting jobs and skills.

4. Labour market polarization is significant.

5. The hybridization of work and skills is significant.

6. Digitalization is likely to affect the way people do their jobs, rather than entirely replacing them, so that there is complementarity between people and machines,

7. The coronavirus disease (COVID-19) pandemic has had a profound effect on the pace of digitalization and on jobs and skills.

8. Education and training are essential to provide the digital, cognitive and transversal skills that young people entering the workforce and adults seeking to upskill and reskill require.

Four issues of particular significance are highlighted. One, jobs are likely to remain plentiful, but work has polarized between high- and low-skill jobs with the rapid growth of high-skilled and professional occupations which create and deploy new digital technologies, while at the lower end of the labour market, there has a been growth of customer service or manual work that is hard to automate. Jobs in the middle, those which provide administrative and support services, have suffered most from automation. Two, platform working is spreading rapidly because of digitalization and raises questions about the nature of employment. For highly skilled workers capable of keeping their skills current, this may bring enhanced autonomy and flexibility, but for many low-level platforms, working is highly precarious with few employment rights and little or no formal skills development or progression. Three, hybridization is about the blending of skills that are not traditionally combined into job roles but are in increasing demand in the labour market. This includes the addition of digital, soft/transversal and creativity skills in traditional technical and professional roles and the creation of new hybrid roles that arise from digitalization of the economy. Complementarity has become the norm, with systems replacing the most routine aspects of people's jobs, providing the space to enhance non-routine elements, such as problem solving and communications.

▶ The skills needs of the digital and knowledge economies

The report discusses the skills requirements deriving from the shift to digital and knowledge-based economies, including the types of digital skills; the demand for these in the labour market, including for vendor qualifications and digital badges; the patterns of digital skills in different sectors; and the progress in digital skills development. It explores the importance of cognitive and social skills development, intertwined with technical skills, as the key to unlocking the successful deployment of digital technologies and the best opportunities for people to adapt in rapidly changing labour markets. It explores how technical and vocational education and training (TVET) systems should respond to these new skills and poses challenges that apprenticeship systems need to address.

The report also explores a range of different digital skills frameworks including those by the Organisation for Economic Co-operation and Development (OECD), the European Digital Competence Framework for Citizens (DigComp), the Broadband Commission, Ecorys, Cedefop and Burning Glass. It draws on Ecorys's work to highlight three broad categories of digital skills: basic digital literacy skills needed by everyone to use and communicate in a digital economy; general and specific workforce skills for digital users; and digital skills for information technology (IT) professionals.

It also draws on Burning Glass' big data analysis of online job postings, of the five skillsets that stand out due to their importance in redefining jobs and shaping entirely new roles: 1) big data and analytics, including the importance of data visualization skills; 2) the intersection of design and development, including designing the usability of the screens we constantly interact with; 3) sales and customer support, including using technology to support the sales process; 4) emerging digital products and languages, for example, the demand for Tableau data visualization software and navigating the evolving compliance and regulatory landscape.

Given the need for digital skills to intertwine with cognitive and interpersonal skills development in support of knowledge-based and digital economies, this report draws on the International Labour Organization's (ILO) global framework on core skills for life and work in the twenty-first century. These skills include teamwork, problem solving, information and communications technology (ICT), communication and language skills, and learning skills and competences to protect the self and colleagues. It is this connection

between digital skills and wider twenty-first century skills that perhaps forms the bridge between digital skills and the skills required for the knowledge economy. The importance of vendor qualifications and the development of digital badging to accredit modular skills updating is also discussed.

Further, this report draws on several sources to explore the current level of digital skills in countries across the world. What emerges is the extent of the gap between the most and least digitally skilled countries. This raises major issues about the digital exclusion of citizens and the ability of countries to remain competitive in the face of rapid digitalization. The ILO, in a report on changing demand for skills in digital economies and societies, reminds us of the "growing developmental gap" where "countries, enterprises and workers that are unable to swiftly adjust to the digital economy risk falling behind" (2021a). This is a situation made worse by the COVID-19 pandemic, which has accelerated digitalization in high-income economies, while widening the gap with lower-income economies and between rural and urban areas across the gender divide and amongst families with different income levels.

▶ Responding to these skills challenges

The report argues that TVET systems need to respond to the different skills needs that people have according to their relationship with digital technologies. It highlights eight issues that need to be addressed while shaping a skills response to digitalization: digital literacy for all, lifelong learning, skills updating, higher- and degree-level skills, improved pathways and progression, greater flexibility in learning design including modularization, vendor qualifications, and digital badging.

▶ Challenges for apprenticeships

Several challenges need to be addressed if apprenticeships are to remain a valid and valuable tool of skills development going forward. These challenges include:

1. Strategic and policy challenges: How can apprenticeships be positioned to meet the wide range of demands for digital skills and stay relevant in economies that have become more polarized, with low-skilled platform work at one end of the labour market and strong demand for high level skills at the other? Should apprenticeships primarily remain the way in which young people are given initial skills or should they take on a wider role in supporting professional development and reskilling? What role should apprenticeships play in developing higher- and degree-level digital skills?

2. Curriculum and teaching challenges: How can apprenticeships be kept relevant and up to date in the face of rapid technological and occupational changes and be designed to allow continuous adaptation and skills development throughout life? It is also important to support training institutions to successfully teach digital skills when their staff may lack the necessary digital skills, recent workplace exposure or adequate facilities and equipment.

3. Accreditation challenges: How can institutions provide appropriate apprenticeship accreditation for digital and wider transversal skills and where smaller and modular programmes are needed for reskilling and upskilling? Also, how can they address the issue of vendor-specific accreditations which may carry greater currency than national qualifications?

4. Inclusion challenges: How can access to apprenticeships be arranged so that no one is left behind by digitalization and the wider polarizing effect on the labour market?

5. Funding and delivery challenges: How can the cost of adapting apprenticeships to support the needs of digital and knowledge-based economies be met? How can a sustainable funding mechanism, including the cost of off-the-job learning, incentives to encourage employer engagement and possible stipends for learners, be established? Should centres of excellence or specialization in digital skills be developed?

Each of these challenges is explored in detail in Chapter 4 of the report, using four case study countries (India, England, Australia and Singapore) to identify what works and highlight obstacles to policy success.

▶ Recommendations

This report makes recommendations in relation to each of the challenges of apprenticeships as set out in the previous section. While some of these are generic issues facing all apprenticeship systems, they are heightened by meeting the challenge of digitalization. The recommendations are divided into "essential" and "radical" options. This summary highlights 18 of the 44 recommendations in the report

▶ Essential recommendations

▶ Engage business and other key stakeholders to shape a clear strategy for digital skills development in which the role of apprenticeships is clearly located. Use the concepts of digital literacy, user skills and professional IT skills to allow a clear focus on the hierarchy and range of skills required.

▶ Strengthen skills anticipation and improve the matching of the demand and supply of skills by using labour market information and analysis to track the speed of digitalization and its effect on jobs and skills, including hybridization and the emergence of new occupations.

▶ Bring employers together to develop standards for digital occupations guided by an overall occupational map, with clear progression pathways and flexibility to move from vocational education and apprenticeships to higher education.

▶ Strengthen existing apprenticeships for young people by adding digital literacy, digital user skills and a wider package of cognitive and social skills development to all occupational frameworks, which are appropriately contextualized by occupation and level.

▶ Consider how standards could be modularized, as in Australia, so that they can used more flexibly for skills updating.

▶ Develop a set of generic digital literacy standards that can be included in all occupational profiles to ensure all apprentices have a basic grounding in digital skills.

▶ Retain a minimum proportion of off-the-job training to ensure people have the time to build fundamental knowledge and a wider understanding in support of the knowledge-based economy.

▶ Support training institutions to recruit, train, develop and retain staff with the necessary depth of digital skills to be credible to industry, with the ability to acquire excellent teaching and mentoring skills. Prioritize staff development and support digital and online teaching.

▶ Adopt a "no one left behind" policy when tailoring apprenticeships to meet the challenges of digitalization, recognizing the persistent gender imbalance in IT occupations. Influence young people early so that they build digital literacy, including understanding the opportunities provided by work in digital occupations and how attractive these can be for women. Provide positive action incentives to meet the additional costs generated when employers take on apprentices with disability.

▶ Fund development projects to adapt, develop, pilot and support the implementation of apprenticeships to meet digital user and maker[1] skills needs, including funding to support staff development, facilities and equipment. Equip training institutions with industry standard facilities,

equipment and software, fast broadband connections, and access to laptops/devices, which should be updated on a regular basis. Government capital grants should be supplemented with private partnership support from vendors and the local business community.

▶ Develop employer incentives to accelerate the scale and speed that digital skills apprenticeships are taken up, especially during the COVID-19 pandemic. Consider applying these incentives on a first-use basis to maximize the impact of public funding.

▶ Support the creation of sector skills bodies and links to chambers of commerce, to co-ordinate the development and delivery of digital user skills apprenticeships.

▶ Radical recommendations

▶ Use big data rather than conventional labour market information surveys to obtain real-time information on the digital skills that are in demand.

▶ Create partnerships between businesses, universities and TVET institutions to explore the need for higher- and degree-level apprenticeships in digital skills and encourage higher skills apprenticeship pilots.

▶ Use apprenticeships to support the updating of digital user skills in the workforce including by rethinking the concept of on- and off-the-job training to support more flexible and bite-sized apprenticeships based on modular standards using blended learning.

▶ Present these apprenticeships with a wider range of work-based digital user skills development programmes for adults on an online digital skills portal (as in Singapore) to raise awareness of the opportunities for all citizens.

▶ Consider how micro-credentials or badges can be incorporated within the framework of assessment for apprenticeships in digital skills to reward the achievement of modules or units of learning.

▶ Encourage the development of digital apprenticeship centres of excellence. These would function as partnerships between quality training providers and employers to co-design and deliver digital literacy, user skills and high-level skills through apprenticeships that meet the needs of specific industries.

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1 The term "digital makers" is used in this report to denote those create digital technologies rather than use them as tools in their work.
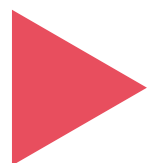
▶ **1** Introduction

Introduction

This paper explores how apprenticeship systems across the world need to change to prepare people for good quality jobs in rapidly changing digital and knowledge-based economies, including how these systems can help people adjust to the changing nature of work.

The paper is structured in five chapters. The first or introductory chapter sets the scene and defines the main terms used throughout the paper. The second explores the impact of digitalization on jobs. The third chapter looks at the skills needs of digital and knowledge-based economies, highlighting several challenges for apprenticeship systems. The fourth section draws on evidence from country case studies and other sources to explore good practice and issues in seeking to overcome these challenges. The final section has a set of recommendations designed to help countries consider ways forward in modernizing apprenticeships to meet the challenge of digitalization and the knowledge economy.

▶ 1.1 What are apprenticeships?

The International Labour Organization (ILO) in the Vocational Training Recommendation, 1962 (No. 117) defines quality apprenticeships as having the following features:

Quality apprenticeships are a unique form of technical vocational education and training, combining on-the-job training and off-the-job learning, which enable learners from all walks of life to acquire the knowledge, skills and competencies required to carry out a specific occupation. They are regulated and financed by laws and collective agreements and policy decisions arising from social dialogue and require a written contract that details the respective roles and responsibilities of the apprentice and the employer; they also provide the apprentice with remuneration and standard social protection coverage. Following a clearly defined and structured period of training and the successful completion of a formal assessment, apprentices obtain a recognized qualification.

▶ 1.2 What is the digital economy and the knowledge-based economy and how are they related?

The Organisation for Economic Co-operation and Development ([OECD] OECD 2005) suggests the following definition of the knowledge-based economy: "'The knowledge-based economy' is an expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high skill levels, and the increasing need for ready access to all of these by the business and public sectors." Brinkley (2007) quotes the UK's Economic and Social Research Council (ESRC)as: "Economic success is increasingly based on upon the effective utilization of intangible assets such as knowledge, skills and

innovative potential as the key resource for competitive advantage. The term 'knowledge economy' is used to describe this emerging economic structure.".

By contrast, Heath and Micallef (2020) argue "the digital economy is the economic activity that results from billions of everyday online connections among people, businesses, devices, data, and processes. The backbone of the digital economy is hyperconnectivity which means growing interconnectedness of people, organisations, and machines that results from the Internet, mobile technology and the internet of things. The digital economy is taking shape and undermining conventional notions about how businesses are structured; how firms interact; and how consumers obtain services, information, and goods."

The concept of a knowledge-based economy predates that of the digital economy. Knowledge-based economies are based on intellectual capital, where, according to Hayes (2021), the commercialization of scientific discovery and research becomes a substantial component of the economy, and there is significant value in intangible assets, such as workers' knowledge and intellectual property. These are societies that, according to the Chen and Dahlman (2006) rely on good education and skills development systems, strong information technology (IT) infrastructure, and a vibrant innovation culture. Hayes argues that knowledge economies grow as part of the sequence of economic development that moves from an agrarian to a manufacturing and to a service-based structure over time.

The digital economy is the next step on this journey, according to Woods (2016), "pushing the knowledge economy to the margins" as the internet of things (IoT), artificial intelligence (AI) and the growth of sharing and collaboration platforms disrupt business processes and make it more difficult to maintain competitive advantages by holding on to intellectual capital. Examples such as Wikipedia, Spotify, and more recently, mobile payment apps, show the power of digitalization, or the growth of the digital economy, to disrupt traditional business models. While digitalization is undoubtedly disruptive, Woods may be writing off the concept of the knowledge-based economy too quickly. The continuing domination of Microsoft, Apple and Google in the technology market arguably shows that yesterday's digital disruptors become today's global players shaping the knowledge economy.

The knowledge economy recognizes the fundamental importance of intellectual capital derived from effective skills and education systems including apprenticeships. Digitalization highlights the speed, the profound nature of the change and disruption that societies must prepare for, and the need for our education and skills systems to become sufficiently agile in order to cope with the speed of this change. Manyika et al. (2017a) estimated that by 2030 "while less than 5 per cent of occupations can be fully automated, about 60 per cent have at least 30 per cent of activities that can be technically automated".

Automation and robotics have already fundamentally changed engineering and process manufacturing operations, such as vehicle assembly, and chemical and pharmaceutical manufacturing, affecting the nature of blue collar work.[2] More recently, our ability to rapidly process huge amounts of data and the development of AI, together with sophisticated data communications and internet-based sales and marketing, are bringing automation and new ways of working into the office environment, increasingly impacting white collar occupations and professions. A range of new and changing occupations are emerging to manage and exploit these technologies for the benefit of society and to further economic progress.

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2 A further related term, "Industry 4.0", or the Fourth Industrial Revolution, is also worth exploring. Industry 4.0 was coined in Germany to describe the specific effects digitalization has on manufacturing processes. It is defined by Epicor as "a new phase in the Industrial Revolution that focuses heavily on interconnectivity, automation, machine learning, and real-time data". Industry 4.0, also sometimes referred to as smart manufacturing, "marries physical production and operations with smart digital technology, machine learning, and big data to create a more holistic and better connected ecosystem for companies that focus on manufacturing and supply chain management."

▶ **2** **The impact of the digital and knowledge economy on jobs**

The impact of the digital and knowledge economy on jobs

The world's economies are facing huge and complex changes. Traditional, industrial production is adapting to a new and more automated future, driven by the development of digital technologies in design, engineering, manufacturing and distribution. High-income economies have outsourced a proportion of their manufacturing, notably to Southeast Asia, and have seen the rapid growth of service-based economies, where health and care, retail, hospitality, automotive, education, government, energy, communications, and financial services play an increasingly significant role. Low-income economies are being similarly impacted as they urbanize rapidly, develop greater manufacturing capability, and harness the power of online communications to achieve global reach for their goods and services. While the available literature on knowledge economies tends to focus on high-income economies, it is recognized that all economies are affected by digitalization. Indeed, the challenge for lower- and middle-income countries may be even larger as they try to manage this transition with limited resources and possibly less mature education and training systems.

This section of the report identifies eight main issues, which are discussed in turn, arising from the transformation to digital and knowledge-based economies that impact jobs.

▶ Digitalization and the shift to a knowledge economy is inevitably influencing jobs and skills, but the shift is not as all-encompassing as might have been predicted.

▶ Digitalization plays out differentially in different economies.

▶ Digitalization is only one factor affecting jobs and skills.

▶ Labour market polarization is significant.

▶ Hybridization of work and skills is significant.

▶ Digitalization is likely to affect the way people do their jobs, rather than entirely replacing them, so that there is complementarity between people and machines.

▶ The COVID-19 pandemic has had a profound effect on the pace of digitalization and on jobs and skills.

▶ Education and training are essential to provide the digital, cognitive and soft/transversal skills that young people entering the workforce and adults seeking to upskill and reskill require.

▶ 2.1 The influence of digitalization and the shift to a knowledge economy on jobs and skills

Manyika et al. (2017b), in a report published by the McKinsey Global Institute, estimate that 15 per cent of the hours worked globally could be automated by 2030, assuming significantly different technology adoption rates by different countries. Work is likely to be displaced in various occupations, such as the operation of machinery, fast food, data preparation, mortgage origination, paralegal work, accounting and back office services. They argue jobs will change rather than being lost. Jobs that involve managing people, applying expertise and social interactions, will be less affected as will "jobs in unpredictable environments", for example, in occupations such as gardeners, plumbers or providers of childcare and elder care. These jobs will generally see less automation because they are technically difficult to automate and often command relatively lower wages, which makes automation a less attractive business proposition.

At the second meeting of the Global Commission on the Future of Work, the ILO (2018) took a similar view, that the full-time equivalent of work potentially displaced by automation has a midpoint estimate of 15 per cent. In addition, between 3 and 14 per cent of the global workforce would need to switch occupational categories. They argue that managing job transition may be a more significant issue than job creation in this context.

Autor, Mindell and Reynolds (2020) share this view and discuss why there are still so many jobs. They makes three main points:

▶ Work has changed. Automation has complemented work rather than displaced it. Routine tasks within a job are being automated, leaving people to provide more valuable work where they can exercise their judgement, expertise and creativity.

▶ Work in some sectors will decline but will be compensated for by the demand for work in other sectors to meet a seemingly insatiable economic demand as economies become more prosperous.

▶ New work categories are emerging in creating and applying new technologies, providing speciality services and "last mile jobs", such as local delivery services

Overall, ILO research (2021c) shows "the past decade (2009–2019) has seen relatively strong employment growth and falling global unemployment rates, despite economic growth having slowed down, or at least stagnated". Global employment has continued to expand at about 2 per cent, while the growth of the labour force slowed in middle- and high-income countries (from 1.3 per cent to 0.8 per cent in this period) and "employment growth outpaced the average labour force growth" (2021c). The problem, they argue, is that the relationship between the growth of the gross domestic product (GDP) and employment has become less linear in higher-income countries. Low unemployment rates have come at the cost of job polarization and labour underutilization.

▶ 2.2 Digitalization plays out differentially in different economies

The ILO Global Commission on the Future of Work highlights differential impacts in relation to automation, connectivity and innovation. The likelihood of automation will increase as the wage levels in developing economies grow and technology costs reduce. Countries, such as those in Southeast Asia, that have developed supportive skills and physical infrastructure, will automate the fastest and reap positive job and economic benefits.

Other developing countries, such as those in sub-Saharan Africa and South America, may have less national capability to quickly take advantage of digitalization, although the adaptability of individuals and industries should not be underestimated. In India, rapidly growing tech industries use various training platforms, with content provided by Microsoft, LinkedIn and other global players, to rapidly upskill their large young population with an ambition to become "the rising talent capital of the world" (Seth and Saini n.d.)

In a 2019 study of 32 countries by Jacob Poushter for the Pew Research Centre, 60 per cent of adults in emerging and developing countries used the internet, while there was 90 per cent usage in advanced economies. Internet usage continues to rise rapidly in lower- and middle-income economies, but the digital divide remains stark and may inhibit the opportunity to improve access to world markets and supply goods and services globally. The development of the platform economy may provide self-employment opportunities for workers in low- and middle-income economies, although with some dependency risk on platform creation companies.

The spread of economic innovation through low-income countries has been assisted by widespread access to mobile and smartphone technology. According to Poushter (2016), 83 per cent of adults in emerging economies own a mobile and 45 per cent own a smartphone, compared to 94 per cent and 76 per cent respectively in advanced economies. Australia and the USA have 81 per cent smartphone usage, coming in fifth and sixth in their table, with India having the lowest at 24 per cent. People under the age of 35 in all countries are much more likely to have a smartphone than their parents, although older people are catching up fast. In the UK, for example, 93 per cent of young people have a smartphone, while the use of a smartphone by people over the age of 50 rose from 44 per cent to 60 per cent between 2015 and 2018.

Innovation in agriculture will be of particular importance in low-income countries. Smart or technology-enabled farming is already developing rapidly in high-income economies, and the benefits are likely to be diffused more widely as apps allow small farmers to share resources and know-how more effectively. For example, the Hello Tractor app in Nigeria allows farmers to hire tractors and other equipment from each other at a low cost through a simple app-based booking system which also tracks costs and maintenance requirements. In Ethiopia, mobile phone technology, such as iCow is helping farmers (CTA 2017), and blockchain is being developed by IOHK to track coffee exports (Coin Insider 2021); in addition, the M-BIRR mobile money service, through its app, connects smallholder farmers with microfinance institutions, allowing them to conduct financial transactions over their mobile phones.[3]

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3 Ethiopian examples drawn from ILO 2021a, 66.

▶ 2.3 Labour market polarization

Jobs are likely to remain plentiful, but growth in work is likely to take place mainly at the bottom and the top of the labour market, with low-skilled routine work being the most vulnerable. Work has polarized with the rapid growth of high-skilled and professional occupations, which create and deploy new digital technologies in companies like Apple, Microsoft and Google, using digitalization to create new and disruptive products and services like Revolut in mobile banking or ASOS in internet retailing and deploy digital skills, such as data analysis and digital marketing, to enhance existing professions. At the lower end of the labour market, there has a been a rapid growth of service-based occupations in hospitality, care, retail, leisure and sport. These rely on customer service or manual work that is hard to automate.

Jobs in the middle of the labour market, those that provide administrative and support services, have suffered most from automation. As shown in figure 1, this is not just a phenomenon affecting high-GDP economies. Indeed, it would seem to be most pronounced in lower/middle-income countries as they adapt to digitalization. The challenge is that displaced people in middle-skilled roles are likely to "bump down" in the labour market unless there is support in place for them to acquire digital skills. As the middle erodes, it becomes more difficult for people to follow traditional patterns of advancement to higher-level jobs in the workplace.

Frey and Osbourn (2015) describe "job polarization" as the "dominant narrative characterizing how global labour markets are responding to technological change", with employment growth being stronger at the higher- and lower-skills levels, with middle-level jobs based on routine tasks being most vulnerable to automation. They suggest "high-end jobs" that are less likely to be affected are those in managerial and professional occupations that require high-level cognitive and technical skills, such as law, architecture, finance and design. Low-skilled, customer-facing occupations that are "intensive in social and creative skills", such as care and hospitality, are growing and are likely to be less vulnerable than routine manual work in, for example, manufacturing or construction.

Figure 1 illustrates the degree of job polarization taking place in low- and middle-income countries as well as high-income economies.

Figure 1: Global trends in job polarization
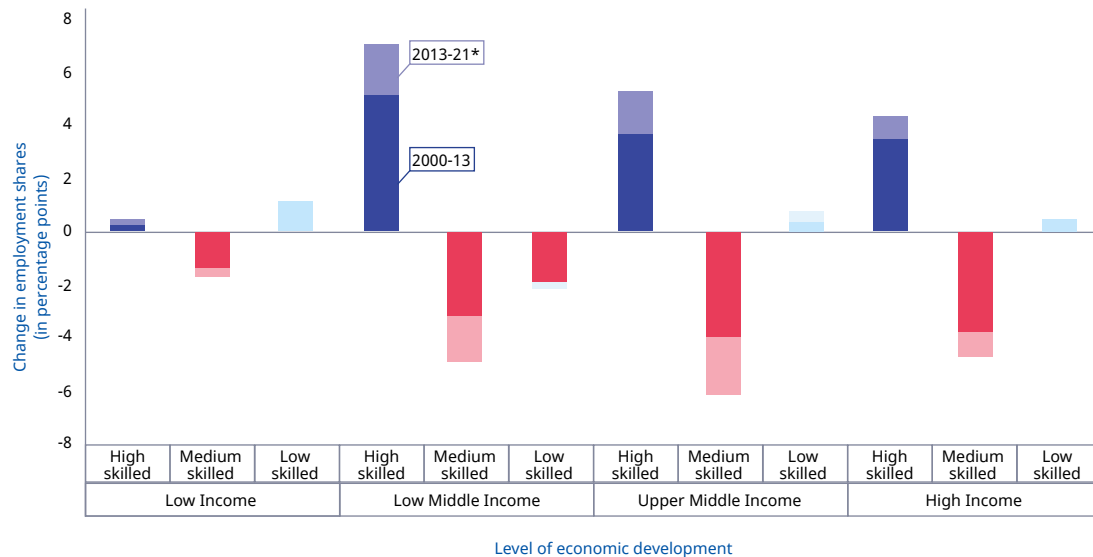
Notes: Change in employment shares, i npercentage points, *Forecasts after 2016,
Source: ILO Trends Economic Models, November 2016

It will be essential that skills development strategies, including apprenticeships, recognize this polarization and provide opportunities for people to use progression through the skills system to help them bridge the missing middle of the labour market. They must also be able to access a wide range of higher-skills opportunities that will be essential in shaping knowledge economies.

▶ 2.4 Platform-based work

Because of digitalization, platform-based work, sometimes called the "gig" or "collaborative" economy or "crowd employment", is spreading rapidly around the world, and it raises questions about the nature of employment, the workplace and workers' skills. Platforms such as Uber, Deliveroo and Taskrabbit are digital labour platforms that outsource work through an open call to a geographically widely dispersed "crowd", or they are apps that allocate work to individuals in a specific geographical area. These models use IT and the internet to harness the skills of individuals in a very flexible way and at high speed. This "just-in-time" workforce has an ambiguous employment relationship with platform owners.

For highly skilled workers, there may be an opportunity for enhanced autonomy and flexibility in an environment where people are fully capable of maintaining the currency of their skills, for many, gig working is highly precarious, with few employment rights and little or no formal skills development or progression.

▶ 2.5 Hybridization of work and skills

Hybridization refers the blending of skills that are not traditionally combined in job roles but that are increasingly in demand in the labour market. This is different from the use of the term "hybrid working" which has emerged through the COVID pandemic as a way of combining work from home and an office. Hybridization is about the nature of jobs rather than where they are located. According research by Sigelman et al. (2019) for Burning Glass Technologies, who applied big data techniques to the labour market through the analysis of millions of job postings on LinkedIn and other platforms. One in eight online job postings are now "highly hybridized", and the report expects the incidence of hybrid jobs to grow by over 20 per cent in the next 10 years. It should, of course, be recognized that this data is likely to be heavily skewed towards high-income economies that are more likely to use online platforms for recruitment.

An early example of hybridization was the rise of mechatronics in German manufacturing, which combined traditional engineering disciplines to create roles that supported systems engineering and industrial automation. More recently, the concept of hybridization has broadened to include the addition of digital and soft/transversal and creativity skills to traditional technical and professional roles and the creation of new hybrid roles arising from digitalization of the economy. Examples from the same research published by Burning Glass include marketing managers gaining a 41 per cent salary premium through acquiring database management and social media competences; customer service managers seeing a 22 per cent rise in salary for the ability to use customer relationship management (CRM) systems; and project managers achieving a 13 per cent rise if they can use Tableau for data visualization.

Roles that the report classified as highly or very highly hybridized include the following occupations: bioinformatician, financial quantitative analyst, data scientist, cybersecurity analyst, computer numerically controlled (CNC) programmer and health information manager. Cybersecurity analysis, for example, requires a deep understanding of computer networks, together with high-level communication and

management skills to persuade companies to strengthen their security systems. These hybridized roles are reaching further and further across economies. Further, the report states that in 2012, only 16 occupations required analysis skills, and this had grown to 35 occupations by 2018. The challenge for educators is that these are not entry-level positions. They require embracing a lifelong learning strategy, and apprenticeships that can adapt to the challenge of hybridization.

▶ 2.6 The effect of digitalization on jobs

David Autor (2014) explains that in 1966, Michael Polanyi observed that there was a paradox in the way we approach life, in that our "tacit knowledge of the world often exceeds our explicit understanding". He uses this paradox to argue it is difficult to automate tasks that we understand only tacitly and in which the explicit "rules" are not fully understood. Work requiring judgment, sensing, intuition and creativity is much more difficult to substitute than routine, codifiable tasks. "Complementarity" has become the norm, with systems replacing the most routine aspects of people's jobs, giving them the space to enhance non-routine elements, such as problem solving and communications.

AI has attempted to overcome the requirement to fully codify tasks before they can be automated, but despite recent progress in areas like translation, there is a risk of overestimating the potential of AI to impact employment. There is also the risk of missing the complexity of seemingly routine work. An interesting qualitative study of German shop-floor production work (Pfeiffer 2018) showed the significant level of non-routine work within production jobs that might be classed as "routine", especially in jobs that require vocational training. The study highlights the importance of experience and knowledge accumulation in producing this work. Pfeiffer argues workers are "more able to handle change and complexity than is often assumed".

▶ 2.7 The Covid-19 pandemic's effect on the pace of skills digitalization

Since March 2020, COVID-19 has dramatically changed the way the world lives and works. Lockdowns have required people to work, study, shop and socialize through the internet and online communication platforms. This has dramatically accelerated the adoption of digital communications across sectors, such as online shopping, telemedicine, remote and teleworking, online schooling, higher education, and training. Work in retail, hospitality, leisure and transport occupations has been hugely affected as air transport, shops, cafes and restaurants and entertainment venues were prevented from operating. While higher-income economies have been able to support furloughed workers and have adequate communications infrastructure to cope with the rapid acceleration of digital services, the pandemic has further widened the digital divide in relation to the access to online services, both within countries and on an international basis, since individuals, social groups and countries with the resources have been able to ensure or boost their online capacities and capabilities.

As countries vaccinate their populations and emerge from the effects of the pandemic, there seems to be pent-up demand to fuel rapid economic recovery. Skills shortages are already appearing in service industry occupations and the demand for technological skills remains high. It remains unclear how far patterns of work will return to "normal" and which of the adjustments made for COVID will remain irreversible.

In the higher education sector in the UK, for example, universities are already planning a future of blended learning, with many staff based at home and smaller campuses focussed on flexible teaching and learning. Denis Pennel, Managing Director of the World Employment Confederation, notes the challenges of continuing to work from home, using teleworking, over an extended period, with greater porosity between the personal and professional, a lack of social interaction, difficulties in building business relationship online, and problems in coordinating and motivating dispersed teams (2020). He argues that new forms of more flexible employment may be necessary to achieve the productivity benefits of not having to travel while retaining the social interaction that builds work teams and is the glue of business relationships.

▶ 2.8 The importance of targeted education and training to foster core skills

Frey and Osbourne (2015) argue that "skilling up" is the main defence for workers, but that gaining the education and training needed is a relatively slower process than the current pace of technological change, creating "a race between technology and education". They send a warning to lower- and middle-income countries that they too may find certain jobs at risk of automation. The effects of this will be felt differently in each country and in some cases, relatively low wages may initially deter the job displacement effects of automation. However, as incomes rise and technology gets cheaper, the need to adapt will increase.

Autor, Mindell and Reynolds (2020) suggest that there will be a scarcity of workers as birth rates continue to decline in many societies, predominantly high-income countries. Their concern is that productivity improvement has been relatively weak because much job creation has been in relatively low value-added services, and technologies tend to lose their transformational effect as they mature until a whole new generation of disruptive technology emerges. The additional utility of each new generation of, for example, mobile phone technology is likely to be relatively marginal. They call for investment in education and to "keep skills rising" to help people to adapt and reskill throughout their lives.
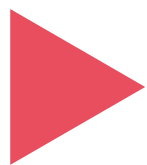
3 **The skills needs of digital and knowledge economies**

The skills needs of digital and knowledge economies

This section of the report will explore in more detail how skills are being affected by the shift towards a digital and knowledge-based economy. It will:

▶ discuss the skills requirements that derive from the shift to digital and knowledge-based economies, including the types of digital skills, specific skills needed, progress on digital skills. and real demand in the labour market;

▶ explore the importance of cognitive and social skills development, along with higher-level technical skills, as the key to unlocking the successful deployment of digital technologies and as the best opportunity for people to adapt in rapidly changing labour markets;

▶ examine patterns of digital skills in different sectors and occupations; and

▶ explore how programmes and qualifications should respond to these new skills and conclude with key challenges that apprenticeship systems need to address.

It is easy to agree that we need to keep skills rising to help people to adapt to digitalization and the knowledge-based economy. TVET, in general, has a crucial role to play in giving individuals the capacity to react to societal and economic transformation. The main questions are what types of skills are going to be needed and by whom?

The concept of knowledge-based economies and "knowledge workers" draws on the idea of knowledge and information being central to driving innovation and productivity in society. It is where high-skilled jobs are the foundation for employment and economic growth, and the economy relies on an education system that provides high levels of literacy and numeracy and cognitive and wider employability skills that are typically developed through tertiary education.

Much of the literature on the knowledge-economy is now rather dated, possibly reflecting that academic attention has tended to move to digitalization in the last ten years, but an OECD analysis of the competencies required (2001) provides a useful insight. They point to continuing growth in managerial, professional, technical and administrative occupations in 14 out of 21 OECD countries for which data was available. This applies to both the manufacturing and service industries and within specific occupations. The OECD argues that greater advances in the general level of education are needed to better prepare workers with the core educational and cognitive skills they need today and to "improve the likelihood of lifelong learning". They also point to the workplace competencies required by knowledge workers, including communication skills, learning ability, team working, and interpersonal and IT skills. These core skills will be discussed in more detail later in this chapter.

For apprenticeships to remain relevant in this context, they need to be more than just a vehicle to impart the technical skills required at a particular moment in time. They need to be able to encourage the development of wider workplace competences, including the social skills set out above and the ability to

look beyond the present day and adapt to changing circumstances. They need to be part of a wider system of tertiary education that allows people to continue or re-enter learning and that has pathways between apprenticeship and higher education.

IT or digital competence is also critical, given the need to be able to gather, interpret and use information to drive innovation and growth. It is these digital skills that we turn to next. An ILO report (2021a) on the changing demand for skills in digital economies highlights a wide range of definitions and categorizations of digital skills including academic, business-oriented, and supply- and demand-focussed perspectives. These range from seeing digital skills in the 2000s as little more than internet user skills, or the skills to use digital media, to approaches that separate personal use from business application, and to more complex frameworks such as those of the Broadband Commission (2017) that separates basic, functional digital skills for rudimentary access from more advanced generic digital skills and higher-level specialized skills.

On digital literacy, for example, India has a mission called Digital India,[4] which promotes the use of a digital platform for almost every aspect of life, including making payments and arranging bookings and reservations. The mission is to transform India into a digitally empowered society and knowledge economy. The aims of the mission include training 10 million students for IT-sector jobs over five years, with many of these jobs in the growing business process outsourcing sector. Apprenticeship training in India is also now managed through a government portal. There is a need for digital skills in setting up and maintaining these systems and to be able to use these portals effectively. Digital skills have rapidly become generic skills that need to be integrated into existing learning or taken up separately by the country's population.

Carretero, Vuorikari, and Punie, in a report for the European Digital Competence Framework for Citizens (DigComp), group digital competence into five areas: information, communication, digital content creation, safety and problem solving, and they include four categories of proficiency (foundation, intermediate, advanced and highly specialized) for each area of competence (2018). The framework is currently being updated to account for AI, robotics, datafication and emerging issues, such as disinformation and misinformation.

On the demand side, in their report on digital skills, Ecorys separates the different needs that people have according to their relationship with digital technologies through three broad categories of digital skills (2016).

▶ Basic digital literacy skills: These are the skills that everyone needs to confidently use and communicate through digital technologies, including using the internet, mobile phones and video technology as well as knowing how to stay safe online.

▶ Digital skills for the general workforce: These are the skills needed by data-driven decision-makers and the wider workforce to manage, adapt and work with digital systems, including general skills like proficiency with Microsoft Office and specific requirements related to each occupation or sector. They may need to be refreshed on a regular basis.

▶ Digital skills for information and communications technology (ICT) professions: These are the skills for digital makers and refer to the specific higher technical skills needed by people in tech jobs linked to the development of new digital technologies, and new products and services.

Unlike lists of digital skills that would need to be incorporated within the curricula of a digital literacy or generic skills programme, this framework helpfully raises questions about how apprenticeships would need to change structurally to cover these needs.

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4 The Digital India programme is a flagship programme of the Government of India with a vision to transform India into a digitally empowered society and knowledge economy.

▶ 3.1 The importance of non-technical core skills to complement digital skills

There is an important difference to be made between digital skills and the skills needed to succeed in a digital or knowledge-based economy. While technical skills such as those categorized in the previous are necessary, they are not sufficient unless they can be deployed effectively. That is why "twenty-first century skills" are also very important. People need the ability to learn and adapt to rapidly changing digital technologies and to deploy them effectively based on a strong foundation of literacy, numeracy, and higher-level cognitive, social and emotional skills. To understand these wider employability, or transversal skills, it is helpful to look at the ILO's core skills framework in figure 2.

Figure 2. Global framework on core skills for life and work in the twenty-first century

Social and emotional skills
- Communication
- Collaboration and teamwork
- Conflict resolution and negotiation
- Emotional intelligence

Cognitive and metacognitive skills
- Foundational literacies
- Analytical and critical thinking
- Creative and innovative thinking
- Strategic thinking
- Problem-solving and decision-making
- Self-reflection and learning to learn
- Collect, organize and analyse information
- Planning and organizing
- Career management

Basic skills for green jobs
- Environmental awareness
- Waste reduction and waste management
- Energy and water efficiency

Core Skills

Basic digital skills
- Use basic hardware
- Use basic software
- Operate safely in an online environment

Source: ILO 2021b.

The ILO describes core skills as being valuable for employability, managing careers, using digital technology, achieving life goals and contributing to well-being. The framework is based on a Resolution concerning human resources agreed on by the International Labour Conference in 2000 that says: "Individuals are most employable when they have broad-based education and training, basic and portable high-level skills, including teamwork, problem solving, information and communications technology (ICT) and communication and language skills, learning to learn skills and competences to protect themselves and their colleagues against occupational hazards and diseases. This combination of skills enables them to adapt to changes in the world of work" (ILO 2005, para. 33, footnote 1).

David Deming (2017) agrees with the specific importance of social skills and the ability to work with others in a team. Social interaction is hard to automate, and collaboration (including through solutions that recreate face-to-face collaboration online) allows greater task specialization amongst people, leading to higher productivity. People-focussed jobs that require strong cognitive and interpersonal skills, such as managers, teachers, nurses and lawyers, are growing fast, and products are increasingly co-created with the interaction with customers.

Digital skills need to be intertwined with cognitive and interpersonal skills development as part of a holistic approach to skills development. While digital skills are becoming an essential component of many occupations, effectiveness at work requires much more than technical aptitude. Cyber specialists need to be able to persuade senior managers of the importance of investing in secure systems; system engineers need to be excellent planners; and communicators and data analysts will be ineffective unless

their work can be turned into communicable insight. Foundational skills, such as literacy and numeracy, are an essential precondition to the successful application of digital skills and thus, digital and core skills can be seen to overlap and intertwine. It is this connection between digital skills and wider twenty-first century skills that perhaps forms the bridge between digital skills and the skills required for the knowledge economy.

The ILO (2021a, 59) concludes that digital skills have "several layers from the basic digital literacy skills needed to access technologies ... to transversal ICT skills which enable the meaningful use of technologies in daily life and work and, further, to intermediate and advanced digital skills, imparting specialized knowledge on how to transform existing digital technologies and create new ones. Each of these layers, in turn, represents a continuum of skills." The report suggests that individuals and employers in different sectors and occupations will require different combinations of digital and non-digital skills. The question is whether apprenticeship design and delivery will pay adequate attention to the development of social and cognitive skills with technical skills and draw the right balance between them.

▶ 3.2 Demand for digital skills in the labour market

While the previous section has set out the broad picture in relation to digital skills, what can we say about the types of digital skills that are in demand in the labour market? Big data analysis of on-line job adverts can be used to identify these skills. Cedefop (n.d.) has, for example, used big data to analyse online job vacancies in Europe and identify trends and priorities. Their data shows that the top six most requested skills in 2020 were: working with others; accessing and analysing digital data; using digital tools for collaboration; content creation and problem solving; providing information and support to people; and solving problems. Their data shows that 29.7 per cent of the vacancies in Europe requested skills in accessing and analysing digital data, including 60 per cent of the vacancies in Luxembourg and Italy and 48 per cent in the UK, while that number was 10 per cent or less from Slovenia and Croatia.

Research undertaken by Nania et al., and published by Burning Glass Technologies (2019), argues that digital skills are becoming a "near universal requirement" for employment. It should be noted that since the research covers only online job postings, it is highly skewed to more digitally advanced countries, especially high-income countries and to jobs posted online, which may mean the data are also skewed occupationally. Over two thirds of the occupations covered by the report now specify baseline digital skills, such as Microsoft Office, as an essential entry requirement, and over 82 per cent (of 9.4 million) job openings across low-, medium- and high-skills levels now require digital skills.

The report argues that job seekers must go beyond baseline digital skills to develop specific skills to advance their career progression. These skills include being able to use productivity tools that complement human skills in areas such as computer-aided design for engineers, Adobe Photoshop for creatives, programming languages for analysts, and CRM software skills for sales and marketing professionals. Such specific digital skills are required in 28 per cent of low-skill jobs listed on their database, 56 per cent of middle-skill jobs, and 68 per cent of high-skill jobs, although demand varies significantly by region and locality and is linked to the intensity and type of industrial sector. However, the report also emphasizes that technical skills do not exist in isolation. Employability and creative skills are also important to employers, with communication the third-most requested skill for IT support staff.

The research focuses on understanding the demand in eight clusters of digital skills: productivity software, (classified as "baseline" digital skills); software and programming; networking systems; data analysis; digital marketing: digital design; CRM and machining; and manufacturing technology. The report

highlights five skill sets that stand out in their importance in redefining jobs and shaping entirely new roles:

▶ big data and analytics, including the importance of data visualization skills

▶ the intersection of design and development, including designing the usability of the screens we constantly interact with

▶ sales and customer support, including using technology to support the sales process

▶ knowledge of emerging digital products and languages; for example, the demand for knowledge of the Tableau data visualization platform saw an 1100 per cent increase from 2013 to 2018

▶ Navigating the evolving compliance and regulatory landscape, including legal compliance, auditing, medical coding skills

While digital skills are in demand in all sectors, technology and service industries have the most intense demand with a particular focus in financial services and the IT and communications sector. Healthcare, by contrast, has a relatively lower demand for digital skills. In addition, large companies tend to have higher demand than smaller firms. Productivity software experience is in the highest demand (which is not surprising since it constitutes a baseline digital skill requirement) followed by programming, computer and network support, and data analysis.

Nania et al conclude that:

▶ baseline skills will get a person a job, but specific digital skills are needed to "power a career" (within occupations that are in their data set).

▶ the possession of in-demand digital skills will help people adapt as jobs change and build resilience in a rapidly changing labour market.

▶ digital skills are in demand across economies, with the fastest growing demand in data analysis and digital marketing.

▶ digital skills help people be more effective, but people need both digital and wider skills.

▶ policy should be shaped to recognize the dynamism of this labour market.

An important response to the high level of demand for digital skills has been the growth of vendor qualifications and digital badges to support both initial training and upskilling. For entry-level jobs, employers often describe their job requirements in terms of specific software tools, such as Microsoft Office or Adobe Photoshop, while TVET systems tend to accredit broader qualifications and apprenticeships that put the use of these tools in a broader context. At the IT professional level, taking cyber security as an example, vendor-specific certifications cover specific information security software platforms, such as the Fortinet Network Security Expert Program, an eight-level certification course for security professionals, which starts from the foundation level and goes to fully designing and installing a network security platform. The Cisco Certified Network Associate (CCNA) is a network switching and routing certification that is a de facto requirement for organizations using Cisco network products.

Currently, IBM, Microsoft, Google, Oracle, SAP, Hewlett Packard and CISCO have gone further by embracing digital badges to support their vendor certifications. IBM has a programme of "badge families" linked to cloud and mobile computing skills and enterprise design. This form of micro-credentialling, attractive to employers, is growing rapidly and is not confined to digital skills. For example, the Artevelde University in Ghent (n.d.) has developed a digital badge system for the accreditation of twenty-first century skills, including digital literacy, global citizenship, entrepreneurship and research skills.

Together with Pearson and City and Guilds, leading tech employers have adopted the Mozilla Open Badges standard as the basis for their respective credentialling programmes to bring some standardization to this new market. This allows any organization to develop and issue badges while allowing the portability of data. However, it does not tie these credentials to a common competency model or standard, raising substantial concerns about quality assurance and control, potentially undermining trust in the badges. This is likely to become a highly confusing marketplace for individuals and employers to navigate as the pace of adoption accelerates and runs the risk of moving towards a much narrower and task-specific skills focus when individuals may benefit more from a broad-based set of skills that opens up occupational choice rather than constraining it.

The advantages of digital badges are that they visible in the digital world, making it quicker and easier for individuals to signal their credentials and for employers to verify them. Vendors may thus be more agile in responding to needs than traditional TVET systems and in keeping pace with changing labour market needs. Badges may be of particular value for digital skills that are in demand globally. Paul Jagger (2019) believes digital badges have "immense value" for the IT sector and are likely to become a "truly exchangeable form of skills currency". These badges could also bring benefits to lower-income economies, enabling them to deliver certificated digital skills without developing country-specific qualifications. This does, however, raise complex issues about integrating digital badging into mature TVET and apprenticeship systems.

▶ 3.3 Patterns of digital skills requirements in different sectors and occupations

The snapshots included in Appendix 1 illustrate how digitalization is having a profound impact in three key sectors of the world's economy – healthcare, financial services and manufacturing.[5] While these analyses draw heavily on the impact on higher-income economies that have been affected earlier than lower- and middle-income economies, the disruptive effects of digitalization are expected to create change across the globe, with the ability of sectors to obtain competitive advantages being depending on the degree of

5 The analyses in these case studies are drawn from Kispeter 2018.

their investment in capital, intellectual property, innovation and skills. It is recognized that the COVID-19 pandemic has altered the trajectory of digitalization and digital skills development in different ways, with acceleration in, for example, the digital communications sector, while healthcare systems have been under intense pressure. It is currently difficult to predict the exact post-COVID effects, although the UK has seen acute skills shortages emerging in many sectors in early 2022 as the economy begins to recover.

▶ 3.4 Progress on digital skills development

In terms of how far digital skills have developed internationally, the picture is not very encouraging. More than 50 per cent of adults across 28 OECD countries could only carry out the simplest of computer tasks, such as writing a basic email or browsing the web, or they had no computing skills at all (OECD 2016). Only a third of workers had the cognitive skills to evaluate problems and find solutions, and many workers use ICT regularly without adequate ICT skills.

On average, over 40 per cent of those using software at work every day did not have the skills required to use digital technologies effectively (OECD 2016). Younger people do better, with 42 per cent of adults aged 25 to 34 being able to "complete tasks involving multiple steps" and requiring the use of specific technology applications, while in the age group 55–65 years, only 1 in 10 could do so. The OECD report concluded that "although most young people seem ready to interact with technology, there is still a large share of youth with low levels of proficiency" (2016).

The International Digital Economy and Society Index report (I-DESI), which compared 45 countries, (the 27 EU Member States and 18 non-EU Member States),[6] paints a less gloomy picture (European Commission 2020). The leading country on the Digital Economy and Society Index (DESI) was Finland, with Denmark in second place and Iceland, the leading non-EU country, third. On internet usage, 82.6 per cent of the EU population were internet users (82.2 per cent non-EU), with 57.6 per cent (66 per cent non-EU) using social media and 57.2 per cent using internet banking.

Leading countries such as Iceland, Norway and the USA far exceeded this, with over 94 per cent of the population using the internet, and over 87 per cent using internet banking. Internet shopping users ranged from 33.1 per cent in the bottom four EU states[7] (21.7 per cent non-EU) to 81.3 per cent in the top four,[8] averaging 79.7 per cent (55.9 per cent non-EU). It is assumed that the COVID-19 pandemic will have significantly accelerated these trends.

In terms of skills, an average of 49.7 per cent of EU and non-EU internet users had basic skills such as word processing, with more than 70 per cent in the top four EU and two non-EU countries. An average of 28.7 per cent had "above basic skills", such as spreadsheet usage, in both EU and non-EU countries. In terms of the population with "at least basic software skills", such as coding, 5.7 per cent and 7.8 per cent had these skills in both EU and non-EU countries respectively. Of all EU and non-EU graduates, 4.3 per cent and 4 per cent respectively were in ICT disciplines, with over 6 per cent being in the top 4 EU Member States. Figure 3 shows how countries have developed on these human capital dimensions of the index between 2015–18.

The most concerning aspect is the huge gap between the most and least digitally skilled countries, which raises major issues about digital exclusion for citizens and the ability of countries to remain competitive

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6 These countries were: Australia, Brazil, Canada, Chile, China, Iceland, Israel, Japan, Mexico, New Zealand, Norway, Russia, Serbia, South Korea, Switzerland, Turkey, United Kingdom, and the United States.

7 The main DESI shows Poland, Italy, Romania and Slovakia as the bottom four EU Member States.

8 The main DESI index shows Denmark, Finland, Luxembourg and the Netherlands as the top four EU Member States.

in the face of rapid digitalization (see figure 4). Countries like Turkey and Chile (with low scores on the chart) have a massive human resources gap compared with high-income economies, such as those in Scandinavia, the USA and Australia.

Research from the ILO (2021a) reminds us of the "growing developmental gap" where "countries, enterprises and workers that are unable to swiftly adjust to the digital economy, risk falling behind", a situation made worse by the COVID-19 pandemic, which has speeded up digitalization in high-income economies while further widening the gap to lower-income economies, between rural and urban areas due to variable access to the internet, across the gender divide and amongst families with different income levels. The ILO also points to the plight of people in parts of sub-Saharan Africa and South Asia, highlighting the approximately 25 per cent use of e-mail in Chad, Nigeria and Myanmar compared with 70 per cent in Ghana, Benin, Mali and Senegal and 54 per cent in Pakistan.

Figure 3. Average performance scores for the human capital dimension of the desi
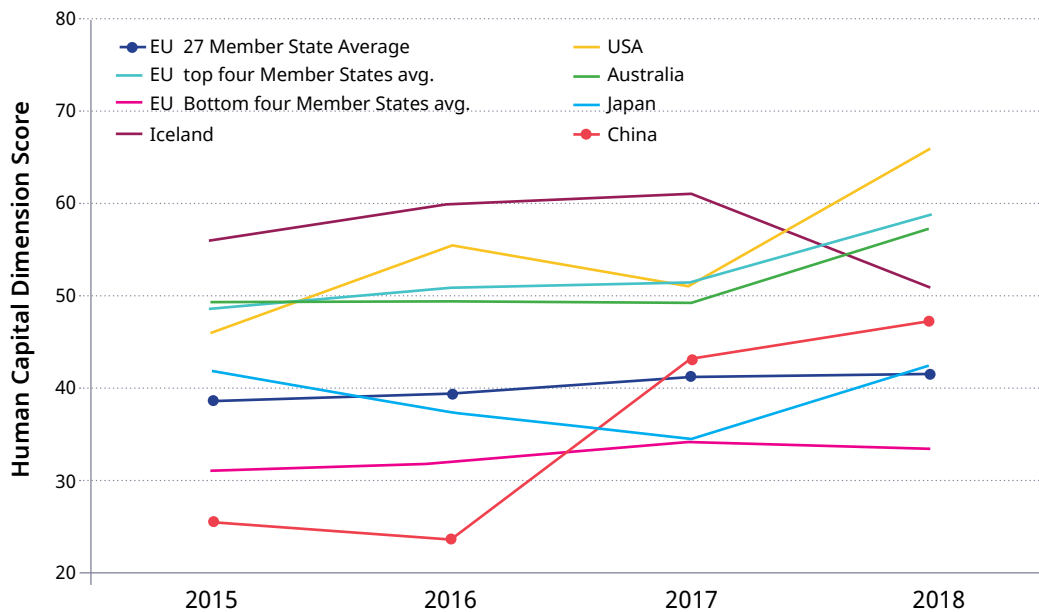
Source: DESI 2020, 22

Figure 4. Normalized scores showing the human resources gap between countries from the desi
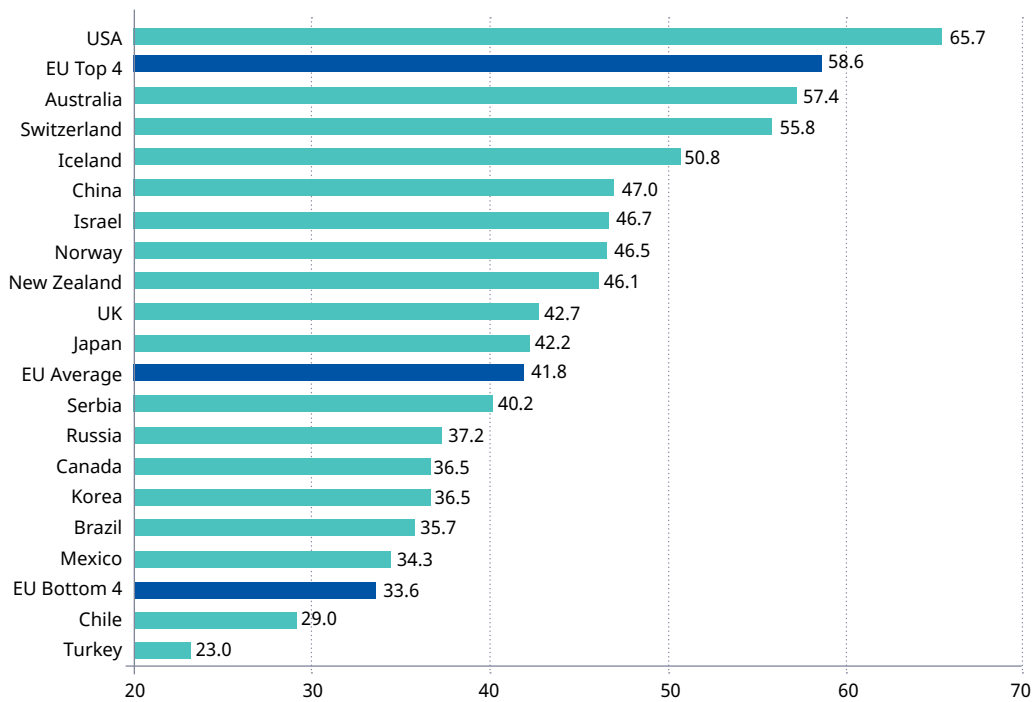
Source: DESI 2020, 23.

The ITU ICT Development Index (IDI) combined 11 indicators of IT access, use and skills into a single measure to allow comparative analysis between 176 countries and over time (2017) (see figure 5. The index shows the strong relationship between economic prosperity and ICT development, with the least developed countries taking 37 of 44 places in the lowest ICT quartile and the top rankings going to Iceland, 6 European countries and 3 from the Asia- Pacific region.

Figure 5. Distribution of idi values between regions
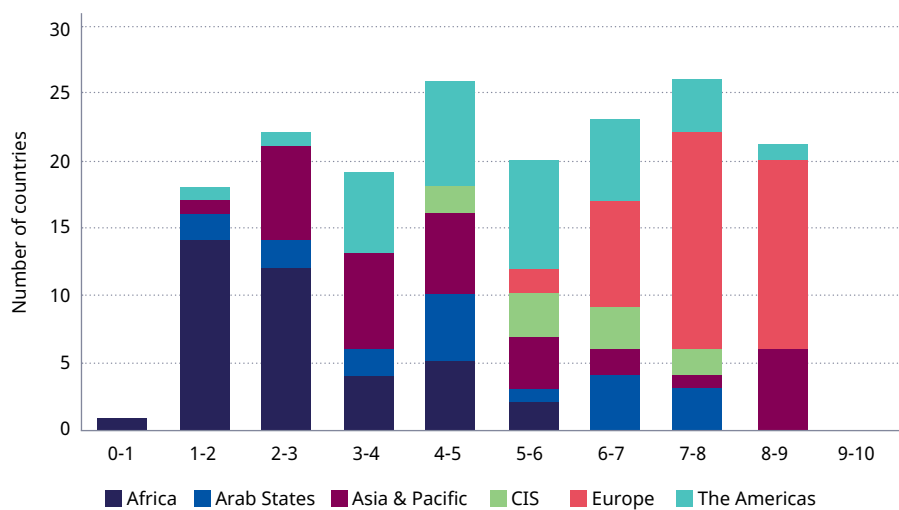
Source: ITU, 2017

▶ 3.5 Responding to these skills challenges

There is a joint responsibility to be borne by governments, employers and individuals to build the skills needed to allow digital and knowledge-based economies to flourish. Governments need to create the right conditions, including supporting basic literacy and numeracy of the population, enhancing internet connectivity, and strengthening TVET systems including apprenticeships, to have the agility to keep up with the pace of change as digitalization affects jobs across their economies. Curricula must be up to date, with work-based learning becoming increasingly necessary to provide hands-on experience with the latest technologies and to understand how they are applied in real work environments. National skills systems also need to be supported by efficient administrative systems and processes, together with appropriate incentives, to encourage innovation and rapid responses to employer needs.

Given the Ecorys analysis (2016) quoted in Chapter 3, TVET systems need to be able to respond to people's different skills needs according to their relationship with digital technologies. This report concludes that:

▶ Digital literacy will need to be built into all programmes, including apprenticeships.

▶ Lifelong learning will need to be enhanced to support reskilling for those displaced in the labour market.

▶ Skills updating will be needed by employers to help their workforce manage, adapt and work with digital systems, including when adapting to hybrid working and building stock of the analytical and data management skills now required by digital users.

▶ Higher- and degree-level skills will be in increasing demand to meet the needs of IT professionals across all industries as they adopt digital technologies, and to support a more general need in knowledge-based economies to support more citizens to achieve higher education.

▶ Improved pathways from initial vocational qualifications to higher- and degree-level skills will be needed to help overcome the skills shortage for IT professionals, widen the pool of talent and reduce inequalities for all occupations in a knowledge-based economy.

▶ Greater flexibility will be needed in how people are able to improve their skills and have their learning accredited. Adults in particular need their learning to fit into the complex fabrics of their lives, and they find small or modular programmes attractive while adding on to existing qualifications and updating their skills. Knowledge economies benefit from this general progression in skills, and the rapid development of digital technologies adds additional weight to the need for short modular updating programmes.

▶ Vendor qualifications are a particular issue for digital skills development. International technology companies offer modular online programmes to support training in specific product skills, and employers commonly describe job roles in terms of specific software tools. The use of vendor qualifications raises questions for national qualification systems that prefer to avoid accrediting specific product training and risks forging two parallel systems of digital skills development – the public TVET route and vendor-specific training.

▶ Digital badging further enhances the flexibility of vendor qualifications, but a lack of underlying standards or competence models, and concerns about quality assurance, creates risks in relation to validity and transferability. These have been partly addressed by the adoption of the Mozilla Open Badges standard. The advantage is that the flexibility and agility of vendors allows a more rapid response to labour market needs than some traditional TVET systems and brings digital skills within reach of people in lower-income economies.

▶ 3.6 Challenges for apprenticeships

Having examined the impact of digitalization on jobs, on the skills needed and that are in demand for a digital and knowledge-based economy, and on how TVET systems should respond in general terms, several challenges have emerged, which need to be addressed if apprenticeships are to retain or improve their general status as a valid and valuable tool of skills development. These are:

1. Strategic and policy challenges: How can apprenticeships be positioned to meet the wide range of demands for digital skills and stay relevant in economies that have become more polarized, with low-skilled platform work at one end of the labour market and strong demand for high level skills at the other? Should apprenticeships primarily remain the way in which young people are given initial skills or should they take on a wider role in supporting professional development and reskilling? What role should apprenticeships play in developing higher- and degree-level digital skills?

2. Curriculum and teaching challenges: How can apprenticeships be kept relevant and up to date in the face of rapid technological and occupational changes and be designed to allow continuous adaptation and skills development throughout life? It is also important to support training institutions to successfully teach digital skills when their staff may lack the necessary digital skills, recent workplace exposure or adequate facilities and equipment.

3. Accreditation challenges: How can institutions provide appropriate apprenticeship accreditation for digital and wider transversal skills and where smaller and modular programmes are needed for reskilling and upskilling? Also, how can they address the issue of vendor-specific accreditations which may carry greater currency than national qualifications?

4. Inclusion challenges: How can access to apprenticeships be arranged so that no one is left behind by digitalization and the wider polarizing effect on the labour market?

5. Funding and delivery challenges: How can the cost of adapting apprenticeships to support the needs of digital and knowledge-based economies be met? How can a sustainable funding mechanism, including the cost of off-the-job learning, incentives to encourage employer engagement and possible stipends for learners, be established? Should centres of excellence or specialization in digital skills be developed?

4

Apprenticeship: Meeting challenges to support digital economies and knowledge-based societies

Apprenticeship: Meeting challenges to support digital economies and knowledge-based societies

This chapter looks at examples from current apprenticeship systems to show different ways in which the challenges set out in Chapter 3 are being addressed, to identify what works, and highlight obstacles to policy success. The main evidence is drawn from case studies of systems in Australia, Singapore, India and England. The intention is that a detailed review of activity in a small group of varied countries, which are each experiencing significant digital transformation, is likely to yield a richer set of insights and recommendations than a more superficial look at a wider range of countries. The risk is that only one of the countries has a lower- or middle-income economy, so a small number of additional snapshots have been added to increase this perspective. What is interesting, however, is the degree of similarity in the experience of India with the other (higher income) case study countries in terms of the speed of technological change and its impact.

Apprenticeships, based on "dual" training principles, (combining workplace training and off-the-job learning), have a proven track record in many countries in providing skilled workers for engineering, manufacturing and construction occupations, and more recently the service sector. They provide a powerful way to engage employers in the design and delivery of training tailored to their needs, and they encourage partnerships between firms and training institutions. There is also an important sectoral dimension to apprenticeships. Traditionally, they have supported craft-working skills, and this is still evident in the jewellery making industry in India and Pakistan and in the informal economy of Ghana, with its rich tradition of informal apprenticeships.

Apprenticeships have successfully adapted to meet the changing skills needs of economies as they industrialize and have further adapted to support IT and telecommunications, healthcare and the growth of the service economy. The question is whether and how they can adapt to meet the challenges of digitalization discussed in this report.

> **Box 1. Snapshot of Jamaica**
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> The global services industry in Jamaica has grown by more than 20 per cent per annum since 2015 as US companies have near-sourced call centre operations. This has been good for the Jamaican economy, but further growth has been constrained by challenges in developing supervisory, technical and managerial staff as the industry moved up the value chain from call handling to providing advice on technical issues. A new, industry-led skills council has now developed an apprenticeship programme with over 700 trainees to help tackle this skills shortage. This is helping young people in Jamaica see a more positive future and clearer progression routes in this industry. Lessons from this pilot will be applied to further strengthen the responsiveness of the skills systems in other key sectors of the economy. For more information, see, https://our.today/jamaica-focusing-on-upskilling-talent-in-bpo-sector/.

Source: Author's analysis.

▶ 4.1 Strategic and policy challenges

Each of the four case study countries in this report have addressed the strategic and policy challenge of positioning apprenticeships to support the digital economy and a knowledge-based society in a different way.

In recent years, England has followed a strategy to grow the volume of apprenticeships, broaden their reach and improve quality, backed by industry-driven standards, tough independent quality assurance and high-quality labour market information. The context has been a market-driven, employer demand-focussed approach, underpinned by a target to train 500,000 apprentices a year, in which employers are directly involved in skills anticipation processes. To help achieve this, the government opened apprenticeship access up to adults (since 2004), higher-level apprenticeships (since 2006) and degree-level apprenticeships (since 2016). Apprenticeship numbers doubled from 240,000 to 521,000 between 2009 and 2011, and then stabilized at around 500,000 starts a year. An employer payroll levy of 0.5 per cent was introduced in 2017. This led to a sharp reduction to 376,000 starts, with the COVID-19 pandemic having a further impact with only 319,000 starts in the year from July 2020 to July 2021.

The levy system has focussed employer attention on apprenticeships as a workforce development tool in tackling skill shortages and maximizing their levy recovery. Working with training providers and colleges, employers have taken advantage of the flexibility in the system to rapidly grow the number of higher- and degree-level apprenticeships and to re-brand workforce development programmes as apprenticeships. For example, there has been an unfortunate tendency by companies to label management training programmes for middle managers as apprenticeships so that they can reclaim levy money on them. The impact has been a significant shift in the apprenticeship age structure, with 50 per cent of the current apprentices being over 25 years of age and only 25 per cent being under 19 years. There has also been a change in the level of apprenticeships with only 31 per cent now at the lower ("intermediate") level, while higher- and degree-level apprenticeships have risen from 13 per cent to 25 per cent of total starts since the levy was introduced.

The most recent policy on skills is defined in the policy paper by the UK Department of Education (2021). This has a post-Brexit policy focus on "global Britain", with new emphasis on resolving specific adult skills gaps through short courses (boot camps) in various industries, such as coding, where a new, two-year, full-time, Level 3 digital skills programme (including a 350-hour work placement) is one of 14 sector-specific T Levels being introduced as the technical equivalent of the A Level[9] examination. There are also plans to extend student loan arrangements to support lifelong learning.

Despite recent reductions in the number of apprentices and other recent parallel skills initiatives, apprenticeships remain a key tool for skills development in the UK alongside full-time technical education. Adopting a flexible and employer demand-led approach has provided the opportunity for apprenticeships to be quickly adapted to the demand for digital skills, including for workforce upskilling, and has facilitated the development of pathways to higher- and degree-level skills. The risk with this flexible approach is that the apprenticeship brand could be seen to be diluted, with a lack of appropriate focus on supporting initial skills formation for young people.

Australia is described by Loveder (2020) as facing a major challenge in adapting to the decline in manufacturing, which has been a cornerstone of their economy. It argues the competitiveness of the Australian economy will be shaped by how well and quickly businesses adopt digital technologies, how well they innovate to reach new markets in an increasingly globalized world, how they tackles new and

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9 The A Levels are a subject-based qualification conferred as part of the General Certificate of Education in Britain and a few Commonwealth countries.

impending threats, such as biosecurity and cybercrime, and how successfully Australian workers can adapt to changing jobs.

Loveder sets out a wide range of government initiatives, including CEDA (Durrant-Whyte 2015), which has described Australia as "on the cusp of a new industrial revolution", predicting that up to 40 per cent of Australian jobs could be susceptible to automation in the next 10–15 years, and that Australians will need higher and different skills to operate in the current and future labour market. An essay by Megan Lilly of the Ai Group (2016) is quoted in the report as saying, "We need to re-tool the nation".

On a wider policy front, the Prime Minister's Industry 4.0 taskforce in Australia has entered an agreement with Germany in 2017 to increase collaboration on digital transformation, including a workstream on education and training. Both countries have recognized that digital skills are a key factor in driving competitiveness and have agreed to share good practices on skills development and reskilling. The Australian Industry Standards' report titled The Learning Country: Digital Transformation Skills Strategy (2021) provides the latest policy analysis and recommendations for change. It talks about the double disruption of the pandemic and digital transformation which has rapidly accelerated the adoption of technology, redefining how and where we work.

The Australian apprenticeship system is organized on a federal basis and is split between trade apprenticeships and non-trade traineeships, (including service sector occupations). The system saw substantial growth from the mid-1990s, peaking at 377,000 starts in 2012, at a time when adult and workforce participation was encouraged and incentivized. Policy then changed to define apprenticeship more narrowly, including removing incentives for adult apprenticeships and restricting employers from enrolling existing workers on traineeships. The impact was a sharp reduction in numbers, and apprenticeships were down to 126,000 starts in 2020.

Extensive work has been undertaken on apprenticeship reform in the light of the decline set out in the previous paragraphs. For example, in 2016, an Apprenticeship Reform Advisory Group (ARAG) report by Craig et al. recommended three pillars of change, (incentives, new pre-apprenticeships, and alternative models including higher apprenticeships). The federal government announced a Skilling Australia Fund in 2017 to support up to 300,000 apprenticeships and traineeships, including higher apprenticeships and occupations in high demand. This was to be co-financed with the states and territories, recognizing the highly devolved nature of Australian governance. Temporary wage subsidies have also moderated the impact of COVID on apprenticeship numbers to some extent, but numbers have remained relatively low.

There is now strong interest from industry groups in extending the concept of apprenticeship to higher-level qualifications to meet the needs of the digital economy. Opening up apprenticeships like this is seen as important in responding to the skills needs of industries and in improving the status of apprenticeships as a valued career pathway. Government-funded pilots have been taking place, including an Ai Group-led initiative exploring the development of high-level digital skills through apprenticeship in a high-tech manufacturing environment. These recent pilots have successfully tested higher- and degree-level apprenticeships, but they are not yet fully embedded in Australian policy.

Australia has clearly identified the need to reform its industrial policy and embrace the digitalization of its economy. It has an apprenticeship system that was well tuned to the needs of a more traditional manufacturing environment and a fundamental part of the wider TVET system, and yet it has faced decline despite considerable attempts at reform. The government has, to some extent, grasped and dealt the upskilling challenge through the use of modularized occupational standards, but, arguably, it has not yet fully embraced the challenge of using apprenticeships for higher- and degree-level skills.

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[10] Trade apprenticeships are in sectors such as engineering, manufacturing and construction. Non-trade traineeships include managers, professionals, sales, clerical, community and personal service roles, machinery operators and drivers and labourers.

Singapore is an advanced economy with the second-highest GDP per capita in the world (2022), third behind Denmark and Switzerland on the World Competitiveness rankings (2022), and second to China on the OECD's Programme for International Student Assessment (PISA) rankings (2018). It has built a sophisticated strategy to embrace digitalization. In 2014, it introduced the Smart Nation Programme to support digitalization of the country's infrastructure and economy, and a Ministerial Committee for Digital Transformation has operated since 2020 to create digital jobs, support small firms and encourage workforce development. The Information, Communication and Media Development Authority (IMDA), which operates under the Ministerial Committee, has a Tech Skills Accelerator Company Programme offering upskilling to graduates and mid-career professionals, including placements in IT companies.

These and a wide range of other skills development initiatives were brought together by the Ministry of Education in 2016 under the umbrella term "SkillsFuture" and presented to employers and the public through a sophisticated internet portal. SkillsFuture is described by the Ministry as "a national movement to provide Singaporeans with the opportunities to develop their fullest potential throughout life, regardless of their starting points" (n.d.). The portal acts as a marketplace and content library, where the best global providers of content and learning can come together to provide information to attract interest in an industry, offer online learning opportunities and provide links to in-depth certificate programmes.

Programmes range from taster courses lasting one to two days to modular development programmes run by universities and technical training institutions, mentoring and advice to businesses on how to maximize the benefits of digitalization and full-time graduate and higher skills programmes that include internships in tech companies. There is a strong and growing focus on work-based training across all these programmes. In addition, the Institute of Technical Education (ITE) provides initial vocational education to students leaving school. The ITE is described by the OECD as perhaps the best in the world for TVET (Tucker 2016, 34). It offers over 50 types of apprenticeships and remains a key tool for initial skills formation for young people.

While Singapore has built a strong apprenticeship model through the ITE to support the initial skills development for young people, they have gone much further in developing skills for a digital and knowledge-based economy. Singapore has clearly positioned apprenticeships as a vehicle for the initial training of young people but has taken the work-based learning idea from apprenticeship and applied it to a wide range of other programmes designed to support adult skills updating or to train IT professionals. This is a very different strategy than the one adopted by the UK and Australia, but it seems to have been highly successful.

India has a short window of time to bring about skilling reforms. World Bank research quoted by Business Today (2017) estimates that about 69 per cent of jobs in India are threatened by automation, with huge investment needed in lifelong learning, reskilling and upskilling the digital skills of Indian workers to enable them to keep pace with technological change. By contrast, the digital sector is booming, and skills development is seen as a critical component of success.

According to the National Association of Software and Service Companies (NASSCOM), the IT sector trade body and sector skills council (SSC), over 8,000 firms with a talent pool of 500,000 people are offering digital solutions (Seth and Saini n.d.), though the wider IT industry has an employment base of around 4 million. The government doubled its budget for Digital India to US$480 million in 2018 and has set ambitious targets to grow the digital sector to a US$1 trillion industry.

COVID-19 has accelerated change with Baruah, writing in the Mint, reporting that the Indian IT sector now faces a "talent crunch", with technology service providers seeing a 30 per cent growth in deals and an 80 per cent jump in cloud spending since the start of the pandemic (2021). NASSCOM argues that India has the potential to become the "talent capital of the world", with millions of young people entering the workforce in the next decade as they graduate from colleges and as platform working provides growing opportunities for Indian workers to sell their services globally.

India has led a programme of apprenticeship reform since 2014 to provide a more flexible and employer-focussed system, but adoption has lagged behind targets. A National Apprenticeship Promotion Scheme (NAPS) was launched in 2016, including a national apprenticeship portal, to provide new impetus. The scheme had ambitious targets to increase the number of apprentices from 500,000 in 2016/7 to 2 million by 2019/20. An Apprenticeship Cell was established in each state to promote and monitor the scheme, together with brand ambassadors, awareness-raising workshops and publicity campaigns. Despite this, there were only 305,000 apprentices in India in April 2019 to March 2020 (figures received from the National Skills Development Corporation [NSDC], India), about half in the private sector and half in the federal or state governments.

Concerns have also been expressed about the progress of apprenticeship reform in recent research, (Sharma 2020). These include the low stipends to individual trainees, employers not complying with legislative requirements, questions about the quality of training, a lack of labour market information to support the system, low public awareness of the changes to streamline the programme, and a degree of variability in implementation between different states, exacerbated by the gaps in capacity building and infrastructure development.

While NASSCOM, as the trade body and SSC for the IT sector, continues to support apprenticeship for young people, they have created a radical new skills development model with government support to attract new talent, develop digital skills for IT professionals, support improved digital literacy, and upskill existing workers. The FutureSkills Prime programme has many similarities to SkillsFutures in Singapore, providing a wide range of modular content through an internet portal, offering digital badging, and being supported by leading tech companies. In addition, private sector technology staffing firms are partnering with large corporates to train "fresh" staff for specific roles, with Microsoft Asia leading a major skills development initiative during the pandemic.

What strategies are then working in positioning apprenticeship to support the digital economy and knowledge-based societies and to help workers stay relevant in the face of the changing structure of the labour market? The lessons would seem to be:

▶ There are strategic choices to be made in how to position apprenticeships at the systems level in addressing digital skills. There is no single right answer.

▶ England has extended the traditional role of apprenticeship (in training young people) to cover adult skills development in the workplace using higher- and now degree-level apprenticeships. This has

led to growth in the numbers of adult apprentices and has offered a strong platform for digital skills development. But with reductions in the number of young people applying, concerns about the sustainability of funding and whether the apprenticeship brand has become diluted have emerged.

▶ Australia has a mixed history with apprenticeship for adult workforce development but is looking at this again, and industry is pressing for higher- and degree-level occupations to be included in the system. This case demonstrates the challenges of repositioning apprenticeships, specifically in terms of how to integrate apprenticeship and higher education.

▶ Singapore has retained apprenticeships for initial skills formation but has supplemented them with a range of other modular programmes to support skills updating and higher skills development, many of which have a work-based learning component. This would seem to be a powerful strategy that may help reconceptualize what apprenticeships are in the context of the digital economy.

▶ In India, the insatiable demand for digital skills from a young population is driving them to adopt a similar strategy to Singapore as the growth of online training programmes from global tech companies disrupts traditional TVET patterns. This seems to show that international tech companies may have greater agility than some TVET systems in meeting the rapidly changing needs of digital economies and could step in to strengthen skills where traditional apprenticeship systems have insufficient scale or agility.

▶ The general question posed in some academic literature (Markowitsch and Wittig 2019) is whether apprenticeships will remain as a "distinctive VET offer" where work-based learning and college study are highly integrated, or where a more "pluralistic model" would emerge, with a wide variety of forms of apprenticeship, including secondments and other employer-engaged delivery, adding work-based learning to wider education programmes to meet the lifelong learning needs of knowledge-based economies. The case studies provide good examples of both possible futures. The question is whether the pluralistic model represents the expansion or dilution of apprenticeship.

▶ 4.2 Curriculum and teaching challenges

The curriculum challenge is about keeping apprenticeships relevant and up to date in the face of rapid technological and occupational changes and designing them to allow for continuous adaptation and skills development throughout a worker's life. Each of the case study countries have interesting examples. The teaching challenge is about supporting training institutions to teach digital skills successfully when their staff may lack the necessary digital skills, recent workplace exposure, or adequate facilities and equipment.

England has completed a full update of all its apprenticeship content over the last seven years as part of a fundamental change in approach to competence standard development. The previous system of National Occupational Standards (NOS) and Apprenticeship Frameworks, which were developed by employer-led SSCs, has been replaced by shorter and simpler Trailblazer Standards developed directly by small groups of 10 leading employers in each sector. Standards and apprenticeship development is now under the direction of the Institute for Apprenticeships and Technical Education (IfATE).

The new standards define the knowledge, skills and behaviours required by each occupation and do not now require a separate national qualification. Assessment is conducted through an end test of competence, administered by a separate independent agency, once the employer is satisfied that the

apprentice is ready. The distinction between on- and off-the-job training, which has been a cornerstone of apprenticeship in the UK and in many other countries, has been preserved. The government stipulates that an apprentice must spend at least 20 per cent of their time away from the workplace to gain wider knowledge and understanding of their industry and the technical skills for their occupation that may not be practiced by their employer. This is not always popular with employers, who would prefer apprentices to spend all their time in on-the-job training; however, ensuring apprentice training remains sufficiently broad is an important protection for the transferability of skills in the system.

A wide range of apprenticeship standards have also been developed for digital skills occupations from the intermediate to the degree level. Degree-level apprenticeships are co-developed by employers and universities. In the tech sector, Tech Skills (the training arm of the UK IT industry trade body, Tech UK) has actively promoted and coordinated the development of digital and degree-level apprenticeships. It also accredits the quality of programmes to give employers greater confidence to engage. There are currently 30 universities offering these Tech Industry Gold accredited programmes. The most popular programme at the bachelor's level is the BSc in Digital and Technology Solutions with specializations such as cyber security analyst, network engineer, software engineer, business analyst, data analyst and it consultant. There is also a dedicated cyber security technical degree apprenticeship and a digital user experience UX professional degree apprenticeship. Masters programmes are offered in 10 universities and include subjects such as data analytics and IT strategy, software engineering, cyber security, IT project management, IT strategy and network engineering.

Tech companies, like IBM, Cisco, Capgemini, BT and Accenture, together with major players in the financial services sector, broadcasting and the media, automotive, defence and aerospace, and online retail, are heavily involved in these programmes,. There is also growing demand from the National Health Service, and national and local government, in support of the digitalization of public services. The numbers of apprentices have continued to grow through the pandemic, with 4,000 apprentices now in the programme. Evaluation findings (Lovell 2021) using Higher Education Statistics Agency data show that employers are reporting the value of the programme in being able to tap into a different talent pool, bringing younger people into tech jobs and gaining loyalty and responsibility benefits.

As far as teaching is concerned, England has established a strong focus on quality across the TVET sector. The independent inspectorate of quality, Ofsted, has concentrated attention on analysing

whether effective teaching and learning is taking place, if the intention of that learning is being realized, and if successful outcomes are being achieved. They also look closely at the quality of leadership and management and the degree of support available to students. Their reports on training institutions are made public, and they are required to take urgent action if their assessment falls below the level of "good". This has led to a strong focus on quality issues across the TVET sector in England and in companies that train apprentices.

Colleges have detailed staff development strategies. They employ technically skilled people from industry and train them on how to teach using national teacher training programmes and college-based coaches, who make lesson observations and support individual teacher development plans to continually improve teaching quality. Teachers are also actively supported in developing online lessons and use digital learning tools. The Barnsley College, for example, has several Tech Stars who are experts in the use of technology in learning. Oculus headsets are now used in health studies to look at the workings of the body, provide initial welding training in engineering as well as being programmed by game design students.

Australia's Digital Transformation Skills Strategy by the Australian Industry Standards (2021) includes the development of "future focused training products" to be achieved by "strategically reviewing apprenticeship training packages through the lens of digital transformation and fast-tracking industry changes". This is in response to concern from industry and training providers about the long update cycle for training packages and the idea that training design is not sufficiently agile to address digital skills needs. One interesting trend has been to break down training packages into smaller skillsets that can be customized and used as short courses for skills updating in the workplace. The number of the packages grew rapidly from 20 in 2008 to 1,500 in 2019 (Stanwick and Siekmann 2021), and there were as many as 96,000 people using them by 2019, although enrolments were dominated by a small number of skillsets largely related to compliance and health and safety. The most used package was "the responsible service of alcohol".

There is industry pressure to complete apprenticeships more quickly based on competences rather than time served, and there is also a debate about the relative importance of technical skills and the wider socioemotional and cognitive skills in the provision of apprenticeships. The risk with changing the way occupational standards are developed, especially when they are broken down into smaller units, is that fragmentation takes place along with a multiplicity of overlapping standards that are increasingly focussed on very specific job roles rather than wider occupations. This could be countered by encouraging each sector of the economy to create an occupational map showing how roles sit and fit together and how this intersects with cross-sectoral skills.

As mentioned earlier, there is particular interest from industry groups in extending the concept of apprenticeships to higher-level qualifications, such as associate degrees and diplomas, to meet the needs of the digital economy. This is seen as an important response to the skills needs of industry and improving the status of apprenticeships as a valued career pathway. Several government-funded pilots have been taking place in Australia since 2016, including an Ai Group-led initiative with Siemens and the Swinburne University of Technology, which has explored the development of high-level digital skills through apprenticeship in a high-tech manufacturing environment and developed a diploma and an associate degree in applied technologies.

The two-year curriculum developed for the pilot included computer-aided design (CAD), computer-aided manufacturing (CAM), industrial networking and cloud computing, object-oriented programming, digital control systems, software tools for Industry 4.0, engineering analytics, robotics, cyber security, smart factory distributed control, and smart product design. It was designed with strong industry involvement and validated by an expert group including Festo, Pfizer, the University of Stuttgart in Germany, and the Aalborg University in Denmark. Twenty students started the programme in February 2017, and a second cohort of 17 students was recruited in 2018.

A review by Oliver, Toner and Yasukawa (2019) concluded that the programme had many characteristics of a quality apprenticeship, recruiting highly motivated applicants, delivering Industry 4.0 training that met company needs, and creating articulation arrangements between VET and higher education. Siemens was seen to have played a strong role in the success of the pilot with the apprentices being complimentary about their industrial tutors. Valuable lessons learnt included understanding the challenges in upgrading teaching skills and facilities, the articulation between higher education and VET accreditation, the critical importance of work-based learning through strong employer/training provider partnerships, and the need for flexibility in delivery to accommodate a block release model[11] in a university setting. The study highlighted the importance of having a project management organization like the Ai Group stimulating change and helping shape policy but were concerned about the transferability of the model to other universities that do not have TVET experience.

In particular, the review concluded that it was necessary for both partners to invest large resources in elevating the curriculum content, teacher knowledge and teaching equipment to a level where it met both the needs of industry and the prior learning of students. Swinburne teaching staff were required to teach at a very high intellectual level and use an applied learning method linked with leading research. Company support to Swinburne has allowed them to develop a "Factory of the Future" on campus, which has greatly facilitated their ability to deliver at this level. Given these challenges, the study questioned the transferability of the pilot to other universities that did not have experience of delivering VET learning or lacked strong industry links. They also questioned the transferability across the TVET system, given the large investment in upgrading teacher skills, knowledge and equipment that would be required and the contrast between the speed of change in the technology and "slowness" of getting courses accredited and training packages changed.

Singapore has developed a set of integrated solutions for initial and lifelong learning, including work-based learning, to address the shift to a digital and knowledge-based economy. Apprenticeships seem to be firmly established as part of post-school vocational education provided through the ITE. Work-based learning is also becoming the main way to develop higher-level digital skills, but this is through a flexible framework of short and longer skills development opportunities designed to meet the needs of graduates and mid-career workers. These courses are based around a modular competency acquisition structure and are available on the SkillsFuture portal.

Over 50 different apprenticeships are on offer through the ITE. Programme places are allocated by the government on a planned basis according to current and projected future needs. A master apprenticeship qualification is available for ITE graduates after three years of work experience. This similar to the Meister concept in the German apprenticeship model.

Beyond apprenticeship, a wide range of career development programmes are also being offered to adults, including a two-day digital awareness course and a tripartite initiative called the Tech Skills Accelerator, which is aimed at new graduates and mid-career professionals. This programme offers a range of specialist skills training, upskilling conversion programmes and placement opportunities in ICT companies.

In addition, the Earn and Learn programme, for example, is essentially a graduate apprenticeship, offering structured on-the-job training coupled with institutional learning to equip graduates with relevant industry skills. Other work-study programmes are available in advanced manufacturing, cybersecurity, data analytics, digital media finance, tech enabled services and software engineering.

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[11] A block release model is one in which student study programmes are arranged so that learners are away from the workplace to attend college or university for an extended period of time, say three months each year, to undertake the academic learning that underpins their workplace experience. This is in contrast with day release that is more common in apprenticeships where, for example, students attend college for one day per week.

In India, apprenticeship occupations are divided into more than 260 designated trades,[12] which are those prescribed by the government including engineering and traditional craft occupations. There are also over 450 optional trades, which are those driven by industry demand, including service sector occupations and shaped by SSCs. These have a duration of between six months and three years. The central government sets policy, while delivery is the responsibility of central and state-level agencies. The NSDC has established 37 SSCs, including an SSC for the IT sector, based at NASSCOM, to stimulate employer engagement, develop qualification packs and set occupational standards for training and apprenticeship.

Recognizing the need for a more dynamic and flexible curriculum to support digitalization, the Ministry of Electronics and Information Technology established the Future Skills Prime initiative in conjunction with Indian industry, including the development of a Future Skills portal based on research by a working group. This group identified 155 priority skills across 70 job roles in 10 emerging technologies and set the aim of FutureSkills Prime to reskill 2 million professionals, students and potential employees over a period of five years.

In addition, Microsoft claims that it has trained 3 million people in India during the pandemic as part of a worldwide initiative to train over 30 million people (2021), including through a partnership with LinkedIn and GITHUB, which is a platform work-sharing site. Ahmed Mazhari, President, Microsoft Asia, has said, "reskilling needs to be at the centre of our economic reset" (Microsoft News Center India 2021). In partnership with the central government, the NSDC and NASCOMM, Microsoft has supported students from industrial training institutes to gain digital skills, and they have created an AI initiative that aims to skill 1 million people.

There are many interesting examples of apprenticeship being adapted to the needs of the digital economy in lower-income economies outside these case study countries. Sri Lanka is a case in point.

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[12] "Designated trade" means any trade or occupation or any subject field in engineering or non-engineering or technology or any vocational course that the central government, after consultation with the Central Apprenticeship Council, may, by notification in the official gazette, specify as a designated trade for the purposes of Apprenticeship Act 1961.

Box 2. Snapshot of Sri Lanka

Sri Lanka

Rebuilding after years of civil unrest, the government established SSCs to support skills planning for a number of industries, including construction, hospitality and tourism and IT. It remodelled apprenticeship provisions using international donor funds and was on the cusp of breaking through in the tourism market when the COVID pandemic struck, and borders were closed. There is strong interest in degree-level apprenticeships from the university sector, but challenges remain in finding sustainable resources and local expertise to drive reform. These have been exacerbated by recent economic turbulence.

Source: Author's analysis.

What, then, is working in terms of shaping an apprenticeship curriculum that supports digitalization and the knowledge-based economy, and what are the challenges that may be obstacles in delivering effective curricula and teaching?

▶ Programmes that are based on competence standards and developed with direct employer input have been grown successfully. All the case study countries have relied on a competence-based approach to apprenticeship design.

▶ The role of SSCs or other employer bodies seems important in bringing a collective employers' voice to the table, although England has now moved away from formally recognizing SSCs and relies instead on Trailblazer groups of employers.

▶ The opportunity for apprentices to have some time away from the workplace to acquire broader knowledge and skills is an important cornerstone of many apprenticeship systems and should be preserved as apprenticeships are adapted for the needs of digital and knowledge-based economies. There is an argument that this may be a luxury in short skills updating programmes for adults, but knowledge economies need people with a breadth of skills and the ability to adapt to changing circumstances, so it is a principle that should be preserved going forward.

▶ The speed at which standards and training programmes are refreshed and approved is key. Australia and India have specifically identified the importance of fast-tracking design and approval but recognize the challenge in achieving this.

▶ Strong industry leadership seems to be a key success factor in all the countries.

▶ Singapore, Australia and India have created working groups to determine future digital skills needs and used these to drive innovation in their systems.

▶ Findings have been validated by expert groups internationally or through cooperation with governments overseas.

▶ Three of the countries have identified the need for shorter (modularized) programmes. Australia has modularized its training packages into smaller skillsets. Singapore has developed a range of short, introductory modules and longer, in-depth programmes. India and Singapore have packaged these under a single skills portal to bring focus and coherence to their wide range of offerings. But modularization brings challenges as well as opportunities, particularly where self-managed study creates issues of student motivation, a weakened relationship with teachers, connectivity challenges, and a reliance on access to technology. It is also important to ensure these modularized courses are developed against an overall occupational map to avoid uncontrolled fragmentation of the standards system.

▶ Although outside the formal apprenticeship system, Singapore has emphasized the importance of work-based learning in delivering digital skills. They have effectively created "mini-apprenticeships" to support adult upskilling while not allowing these to be confused with their main apprenticeship brand.

▶ The UK and Singapore have shown the importance of building clear progression routes from initial apprenticeship training to higher-level skills, including pathways for workers to upgrade their skills.

▶ England and Australia have been successful in extending apprenticeships to higher skills and the degree level to meet the pressing skills demand for data analytics, cyber security, software and network development. England has fully embedded degree-level apprenticeships in its TVET system, based on standards and developed by partnerships between the IT sector and specific universities. The Siemens pilot in Australia has shown some of the challenges in establishing programmes of this kind, including upgrading teaching skills and facilities, the articulation between higher education and VET accreditation, the need to build strong employer/training provider partnerships, and the need for flexibility in university delivery.

▶ Global players, such as Microsoft and LinkedIn, have growing influence, through bringing in scale and impact to digital skills development in India outside the formal apprenticeship system.

▶ There may be challenges in recruiting and retaining the quality of staff required to deliver digital skills programmes. It is difficult for training institutions to compete with private sector salaries, given the demand for digital skills across the economy.

▶ There are challenges in keeping staff up to date in such a rapidly changing technological environment. Increasingly, colleges are using online materials to support teaching and are seeking greater interchange with partner companies to maintain the currency of their skills.

▶ 4.3 Accreditation challenges

The accreditation challenge is about providing appropriate apprenticeship accreditation for digital and wider transversal skills, and where the need for upskilling and reskilling means that people may seek smaller or modular programmes to top up their existing qualifications, both for general progression in knowledge economies and to keep on top of digital change. It is possible, over time, that vendor-specific digital skills accreditations may carry greater currency than national qualifications

England has a regulated private market for national qualifications development with over a 150 awarding bodies, including two leading international qualification players, Pearson and City and Guilds. Awarding bodies offer over 11,000 vocational qualifications on a national and international basis with 70 per cent awarded by the largest five awarding bodies. Recognizing the importance of vendor certifications, Pearson has integrated the option to gain the Computing Technology Industry Association (CompTIA) and Cisco certifications alongside their range of BTEC IT qualifications.

Apprenticeship qualifications in England are based on Trailblazer Standards developed by employers and approved by the IfATE. In general, qualifications are regulated by the Office of Qualifications and Examination Regulation, Ofqual, and are held on a national regulated qualification framework called "the Register" which has eight levels. Most apprenticeships are at levels 2 and 3, but with the growth of higher- and degree-level apprenticeships, they are now at levels 4–7. Apprenticeships are now assessed using end tests administered by separate independent providers.

There are 30 apprenticeships covering digital occupations currently available,[13] ranging from digital support technician at level 3 to network engineer at level 4 and digital and technology solutions specialist at level 7. "Technical Levels" have also been recently introduced. These full-time two-year vocational qualifications (at Level 3) are designed to have parity with the general/academic A Level route that prepares young people for university. A digital T Level has been developed alongside 14 other routes. Each has a 350-hour work placement requirement and much more substantial teaching content than previous vocational qualifications. The digital route has five possible options in the second year, (programmer, software developer, network administrator, web designer and IT technician). Early indications are that these are academically demanding programmes that will offer a valuable stepping-stone to higher apprenticeships or university. They are likely to be an attractive option for the IT industry that has more experience of placement-based programmes than apprenticeships.

In India, there are five categories of apprenticeships. Designated trade apprentices (261 trades) take All India Trade Tests after one to two years of training to gain a National Apprenticeship Certificate (NAC). Graduate apprentices and technician apprentices (163 trades) gain a certificate from the Ministry of Education on completion. Optional apprentices, (those designed by employers to meet their own needs outside the "designated" system), can take the All India Trade Tests to gain certification.

NASSCOM acts as the SSC for the IT sector and has produced standards for job roles in AI, IoT, cloud computing and cyber security. NASSCOM has national approval to assess and certificate IT apprentices through its SSC role, and it also offers platform credentials and digital badges for small increments of learning linked to the FutureSkills Prime programmes.

Google India is now offering apprenticeships to graduates and diploma holders in four digital disciplines, (data analytics, digital marketing, IT and project management). In parallel to apprenticeships, Microsoft, through its partnership with LinkedIn Learning and the GITHUB Learning Lab is offering low-cost

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13 For more information, see the Institute for Apprenticeships and Technical Education

Microsoft certifications in 13 programmes that are rapidly expanding the use of vendor qualifications and micro-credentials.

Australia has created Skills Packages, developed by various SSCs, to support apprenticeships and traineeships. There has been a trend towards the modularization of these packages into skillsets for use in workplace upskilling. Apprenticeship programmes are undertaken at different levels from Certificate II to IV and a diploma. Assessment normally takes place on the job and is certified at the state level. Examples include a Certificate II programme in applied digital technologies and a Certificate III programme in IT. Skillsets developed during 2021 in digital skills include cloud design and implementation, cyber incident response, cyber security insider risks and threats, data analysis and support for 5G rollout.

The lessons from this challenge are listed below:

▶ National accreditation models still have an important place in supporting apprenticeship-based digital skills development. Each of the four case study countries has a national- or state-level qualification system underpinned by the assessment of employer-based competencies as defined by employers. Programmes focussed on digital skills are part of this wider framework.

▶ Australia is a good example of the successful modularization of apprenticeship standards into skillsets as part of seeking a better way to enable the general upskilling of the adult workforce and to provide specific modules on digital skills.

▶ Vendor qualifications are important and international qualification providers like Pearson are adapting to embrace them. The power of international tech companies is also significant as Microsoft, Google, LinkedIn and others have moved to support skills development on a global scale. Partnering with agencies like NASSCOM in India, they are starting to change the dynamics of skills development in the digital arena towards accreditation of small units of learning, which are accredited through internationally recognized badges or micro-credentials.

▶ 4.4 Inclusion challenges

Inclusion challenges are about improving access to apprenticeships for women, adults, older people, and minority ethnic communities, and adapting them so that no one is left behind by digitalization. Inclusion recognizes the polarization of labour market risks, including the "bumping down" of people displaced from middle-level jobs into lower skilled and more precarious work at the bottom of the labour market.

Equality, diversity and inclusion needs to be at the heart of skills development. This is achieved with varying levels of success in the case study countries, and inequalities persist in each of their labour markets with high levels of gender segregation on an occupational basis. The inequalities also persist in the differential access to training and employment according to ethnicity and level of economic disadvantage. In the case of digital skills, there are also age-related challenges; older workers may find adapting to digital tools and devices more challenging than young "digital natives".

Digitalization could be seen to exacerbate these issues, polarizing labour markets, stimulating the growth of the gig economy with a growth of part-time and more precarious employment with poorer access to learning and development, and increasing the risk of "bumping down" in the labour market as people in middle-level jobs are displaced by automation. At the same time, digitalization is also a powerful tool in

improving equality and access to opportunity. The rise of platform working allows individuals to sell their programming skills on an international basis whether they are based in London or Delhi.

The internet allows people and businesses to effortlessly communicate across the world, opening personal and trading relationships and networks but also providing a platform for negativity and intrusion. However, more directly relevant to the skills agenda, digital platforms have made it possible to move the knowledge component of TVET learning online during the pandemic to minimize the disruption to learning and keep in close touch with more vulnerable learners. However, this has been a realistic proposition mostly in higher-income countries that have access to high-speed broadband and for students with laptops and internet access at home. This paper seeks to find some examples of national good practices from the case study countries rather than explore diversity issues in depth. It is encouraging that each country shows signs, at the policy level, of an increasing focus on "no one being left behind" and a growing interest in lifelong learning as they develop their digitalization strategies.

England has now achieved an overall gender balance in apprenticeships, but this is largely due to the growth of service sector, customer-facing, healthcare-related apprenticeships. While some progress has been made in encouraging women to take up traditionally male occupations, there remains a high level of segregation by occupation. To counter this, from around Tech Skills had a long-running programme called Computer Clubs for Girls, which was meant to encourage young schoolgirls to explore coding and overcome perceptions that IT was a "geeky" occupation only suitable for young men. The programme was successful at influencing those who took part at the time, but apprenticeships in digital skills remain male dominated.

The UK's Department of Education's skills policy paper (2021), had a strong focus on lifelong learning and include proposals to widen access to the current higher education student loan system to support TVET students. Incentives are available to encourage employers to take on apprentices with disability and to cover the additional costs of their training. Employers currently receive enhanced incentives to take

apprentices during the economic recovery from COVID-19, and the government has funded an extensive programme to provide laptops to disadvantaged students so that they can participate in online learning during lockdowns.

Australia's "Learning Country" strategy adopts the principal of leaving no worker behind. It calls for a greater focus on lifelong learning and to "normalize continual skills development" (Australian Industry Standards 2021). The reduction in the numbers of apprentices since 2012 was partly due to the withdrawal of support by the government for adult skills development in the workplace, and there is much work to be done to translate policy into practice on a state-by-state basis. There are also specific equality issues in Australia relating to the Indigenous population. A package of enhanced employer incentives is available to aid COVID recovery including a wage subsidy element and aid of 123 million Australian dollars over two years to support indigenous communities and businesses.

In India, according to the Apprenticeship India website, there were about half a million apprentices on the apprenticeship programme in 2021 working with 27,000 employers. About half of these apprentices are in the private sector and half in the central or state government. This would seem a low number in a country with a workforce of 485 million people and where 4.8 million apprentices would be needed to match a 1 per cent workforce replacement rate.

Surajit Roy, former Senior Head, Apprenticeship Division, NSDC, recognizes the problem and is optimistic about the future (Subin 2020). He argues that recent reforms now allow any company to develop their own apprenticeship programme, and that with the removal of previous constraints and a national portal for administration, the numbers of optional trade apprentices are set to rise quickly. This is likely to open many new opportunities in non-traditional sectors and create many more openings for young women to participate. In addition, Microsoft, in partnership with the NSDC, has trained 100,000 disadvantaged young women as part of their global skills initiative discussed in this chapter.

Singapore is taking perhaps the most radical and innovative approach to apprenticeships. SkillsFuture is described as "a national movement to provide Singaporeans with the opportunities to develop their fullest potential throughout life, regardless of their starting points" (SkillsFuture n.d.). It is designed around four pillars; well-informed career choices; high-quality education and training that evolves to meet needs; employer recognition of skills; and a culture that fosters lifelong learning.

The SkillsFuture portal is designed in an attractive and inclusive way, and generous grants are available from the government to incentivize individuals and employers to invest in digital skills, including compensation for people to be away from their workplace while upgrading their skills. They are even training street vendors in digital skills to be able to take electronic payments in an increasingly cashless society.

Other countries, like Tanzania, have achieved success in positioning apprenticeship to meet the needs of an increasingly knowledge-based society while addressing issues of inclusion.

Box 3. Snapshot of Tanzania

Banking apprenticeships in Tanzania Banking apprenticeships in Tanzania

Tanzania embarked on apprenticeship programme in 2017, starting with the tourism sector, in response to serious skills shortages, graduates not meeting the needs of the job market, and employers incurring high costs to acquire and train staff. Success in this sector, with 85 per cent of graduates being able to secure full-time employment within three months of graduation and enhanced opportunities for young (mainly Muslim) women, has inspired the adoption of the apprenticeship model in banking and finance. This is the first-time apprenticeship has been used in the knowledge sector in Tanzania.

Two different degree-level apprenticeships were designed, a bachelor's in insurance and risk management and a bachelor's in banking. The programmes are ranked as National Technical Awards (NTA) at levels 7 and 8 respectively. The ILO has provided capacity building and financial support to enable 212 apprentices to be recruited, including 108 women.

The implementation of these programmes has reversed the narrative that apprenticeship is only effective for lower-level skills and has emphasized that adopting an apprenticeship path based on extensive consultation and collaboration with employers can be highly successful.

Source: Author's analysis.

Several strategies look promising in terms of enhancing digital apprenticeship inclusion, such as:

▶ recognizing the extent of the problem and establishing a "no one left behind" policy;

▶ influencing young people at school so that they understand the opportunities provided by work in digital occupations and how attractive these can be for women and other under-represented groups;

▶ providing positive action incentives to meet the additional costs of employers of taking on apprentices with disabilities and learning difficulties;

▶ creating more flexible apprenticeship models, including modularized skillsets, to help people who are unable to commit to full-time apprenticeship study;

▶ building an online portal, as attractive as that of Singapore, to showcase the wide range of work-based skills development opportunities available and how these can support career development; and

▶ engaging the international tech industry to adapt their global skills programmes to fit local needs and culture and seeking their sponsorship to build greater scale into diversity initiatives.

▶ 4.5 Funding and delivery challenges

Funding and delivery challenges are about implementing apprenticeship programmes to support the needs of digital and knowledge-based economies. This includes establishing a sustainable funding mechanism (covering the cost of off-the-job learning, incentives to encourage employer engagement and possible stipends for learners) and ensuring delivery includes ways to engage employers and the development of centres of excellence or specialization in digital skills development.

In Australia, since 2017, the Skilling Australia Fund has incentivized over 300,000 apprenticeships, including higher apprenticeships in occupations in high demand. The fund is co-financed by the federal government along with the states and territories. The problem of this approach, according to Megan Lilly of the Ai Group, is that it is difficult to build sustainable new programmes using "mix-and-match" funding of this type because these sources of funding are time-bound and project-based rather than integrated into the mainstream system (conversation with the author).

On the subject of delivery, Australia has been successful over many years in using group training organizations (GTOs) to coordinate the delivery of apprenticeships amongst smaller companies in a local area. The approximately 200 current GTOs typically act as the training manager for a group of small firms, often from a specific sector typically in engineering or manufacturing, or in a defined geographical area. They employ apprentices and place them in small companies, moving them as necessary to allow them to achieve the full requirements of their training package. They pay wages, support apprentices and track their progress. The opportunity they provide in the digital economy is to be able to reach and support small and medium-sized digital companies to deliver quality apprenticeships without the cost of employing their own training staff.

Singapore has the wealth to be able to offer high levels of public subsidies to individuals and employers to help them acquire and update their digital skills. This includes a training credit system, where individuals are given an allocation of public resources in the form of a credit that they can spend on upskilling, and employers can recoup the costs of upskilling, including the time individuals are away from work. Apprenticeship delivery is undertaken through the ITE, and other digital training takes place through a wide range of training institutes and universities as discussed earlier.

England uses funding to "nudge" behaviour. Funding is attached to each apprentice and tracked through a unique learner number from the place of learning to a national government database. Each standard for an occupation has a different funding level, which is affected by the length, level and complexity of the training, with degree-level apprenticeships attracting the greatest funding. Reducing funding for lower-level business administration programmes has led to a reduction in their uptake, with the focus moving to higher-level programmes where better margins are available. The problem is that higher- and degree-level apprenticeships in digital skills are four or five times more expensive than traditional lower-level apprenticeships.

There is a strong element of output-related funding for the successful and timely completion of the apprenticeship. A 0.5 per cent payroll levy on all employers, including the public sector, raises more than £2 billion annually and covers the cost of the apprenticeship system. This is administered online through a digital apprenticeship service (DAS) that creates online levy accounts for each business. The government tops up the levy accounts of small businesses that are not required to pay the levy. The funds flow back to businesses and their training provider from the DAS when apprentices are recruited. The government also allows the transfer of unused levy account funds to businesses in company supply chains and subsidizes 95 per cent of the cost of off-the-job learning for small companies. Additional employer incentives are provided to encourage apprenticeships in small firms, which have doubled during the COVID pandemic. The rapid growth of high-skill programmes risks destabilizing the levy model if growth continues at the current rate.

Apprenticeship delivery in England takes place through about 200 colleges and a wide range of private training providers that operate in an employer demand-driven system. Colleges are governed and managed on an autonomous basis, appointing their own board and executive teams. They can borrow money commercially to fund college development and are free to design a curriculum to meet local student and employer needs. They are expected to remain financially viable, using government funds and commercial income, and can retain surpluses but as charities, they may not distribute profits. They are subject to rigorous quality inspection to ensure they deliver relevant and high-quality teaching and learning in line with their strategic aims. Recent initiatives in support of digital skills development include short courses called Boot Camps in specific skill shortage areas and the development of institutes of technology delivered by partnerships between universities and colleges in sub-regions to provide centres of specialization in higher-level technology skills.

The work of the Barnsley College demonstrates how the benefits of this demand-driven and flexible approach can be applied to supporting digital skills development. The college works with over 800 companies in south Yorkshire and has built a digital skills hub offering the new T Levels in digital technologies alongside digital apprenticeships for local tech companies. It plans degree-level apprenticeships in software design, cyber security and data analysis, offering incubation facilities to support tech start-ups. It also intends to offer education and business support to tech businesses across the area.

Many of the funding and delivery lessons set out in the following sections would be relevant to the delivery of any quality apprenticeship programme, but their importance is amplified by the challenge of delivering skills to support digital economies and underpin a knowledge-based society. Employers need confidence in the urgency and consistency of the government's response, and the government needs to be sure that adequate funds are available to drive the scale of change required, and they must recognize the higher cost of higher- and degree-level programmes and the development of centres of excellence. Important funding and delivery considerations include the following.

▶ A stable and sustainable apprenticeship funding system supported by efficient administrative arrangements should be established. Levy systems draw in substantial funds but are politically sensitive and can have unintended consequences when employers focus on levy recovery rather than skills development.

▶ It is interesting that both India and the UK have adopted online administration for their apprenticeship systems. This seems like a good way to speed up decision-making, which is important in building employer engagement.

▶ The use of output-related funding attached to individual learner progress and achievement is not widely used, most likely because of administrative complexity, but it is facilitated using electronic data exchanges and online apprenticeship portals. This could be a powerful way to incentivize digital apprenticeships.

▶ Australia has a devolved system where states have control of TVET systems and develop their own funding arrangements and incentives. The federal government also intervenes to address Commonwealth-wide priorities. This is like many other large countries, including India, Pakistan and the nations of the UK. It is a system that can encourage innovation but does not necessarily promote the rapid adoption of new policy nationally.

▶ India, as with many other lower- and middle-income countries, provides direct financial support to apprentices in the form of a stipend. This is necessary where apprentices have trainee, rather than employed, status and receive few employer benefits. However, this may be a less helpful model for apprenticeships in digital occupations.

▶ Other employer incentives to encourage the uptake of apprenticeships can be beneficial in the short term, for example, in re-energizing the apprenticeship market post COVID-19, but the benefits tend to erode over time and can be a disincentive as seen in Australia when they are removed.

▶ For delivery, the use of GTOs to support small firms with apprenticeship delivery could helpfully be extended to support digital skills development.

▶ Autonomy and flexibility for training institutions to design programmes to meet local skills need is also important.

▶ Improving the delivery of digital skills by creating centres of expertise for curriculum and staff development and showcasing links to industry and building specialisms that meet business needs is also important.

▶ **5**
Recommendations

Recommendations

What, then, should governments consider as they prepare to adapt apprenticeship systems to meet the challenge of digitalization and the move to knowledge-based economies? This report makes recommendations in relation to each of the challenges for apprenticeships as set out in the preceding chapters and draws from the good practices described in the case studies in Chapter 4. While some recommendations address generic issues facing all apprenticeship systems, they are heightened by the challenge of meeting various digital skills agendas.

The recommendations are divided into "essential" and "radical" options. Essential recommendations draw on general good practices in quality apprenticeship development and consider how they need to be adjusted to meet the challenges of digitalization. More radical options are those that push the boundaries of apprenticeships to address the skills demands of digitalization and knowledge-based societies that sit outside the normal reach of apprenticeship programmes.

A review of the World Bank's and the African Union's strategies and recommendations relating to skills for digital transformation in Africa (World Bank n.d.; African Union n.d.)(see box 4) show a degree of synergy with the analysis and recommendations in this report and provide some confidence that these recommendations should be applicable to both higher- and lower-income countries in creating a foundation to provide effective support for digitalization and the growth of knowledge-based societies. It is, however, disappointing, that apprenticeships do not form part of their recommendations. This says something about the importance of focussing global attention on the opportunity apprenticeships continue to offer to high- and lower-income countries in managing digitalization if they are appropriately adapted to meet the needs of a changing world. This includes clear positioning within an overall strategy for digitalization, effective curriculum development, an inclusive approach, high-quality teaching and learning, and sustainable funding and delivery.

Box 4. Snapshot of Africa

Digital transformation in Africa

The World Bank, as part of their Digital Economy for Africa initiative, argue that digital technologies have the power to unlock new pathways to economic growth, job creation and access to services that would have been unimaginable a decade ago. Yet, they highlight a growing digital divide since only 22 per cent of the people in Africa had access to the internet in 2017, locking them out of access to services. They suggest businesses are only slowly adopting digital technologies, and few governments are investing strategically and systematically in developing digital infrastructure, services, skills and entrepreneurship. Africa's youth, constituting 60 per cent of the population, need to be empowered with digital skills, access to technology and markets, all of which are essential in order to thrive in an increasingly digitized global economy. It is estimated that 375 million young people will enter labour markets across Africa by 2030.

The World Bank supports the Digital Transformation Strategy for Africa 2020–2030 prepared by the African Union, which argues that the main precondition in realizing the digital transformation of Africa is investment in highly skilled people as producers, consumers and innovators of digital technologies. It quotes from the Pathways to Prosperity Commission and states that digital awareness

will be needed for all, higher-level digital skills in business and government and complimentary socio emotional and cognitive skills. The African Union proposes a detailed series of skills recommendations including:

▶ conducting a demand-skills assessment study of African industry to identify the specific skills required to drive growth;

▶ reviewing education curricula according to current needs and trends of a digital society;

▶ boosting relevant education opportunities and digital skills development for women and girls;

▶ promoting technology-supported learning;

▶ scaling up online higher-level education institutions;

▶ making African institutions centres of excellence delivering ICT training that is in line with market needs;

▶ mainstreaming digital skills and responsible online behaviour among all citizens;

▶ promoting learning opportunities delivered by public and private partners for workers across all sectors, including on-the-job training and rapid skill training; and

▶ supporting the development of national and regional ICT centres of excellence for skills development.

Source: Author's analysis.

▶ 5.1 Strategy and Policy

What role should apprenticeships play in developing higher and degree level digital skills? Are they the right vehicle to meet the wide range of demands for digital skills in an increasingly polarized labour market with the rapid growth of low-level platform working and the gig economy at one end of the labour market and the strong demand for high-level skills at the other? Should apprenticeships remain the primary way in which young people are given initial skills or should they take on a wider role in supporting professional development and reskilling of the adult workforce?

There is no single right answer here. England has progressively opened up apprenticeships to go beyond the initial training of young people and to include adult upskilling in the workplace and more recently, to enable the rapid growth of higher- and degree-level apprenticeships. The advantages of this approach are that employers are able to influence the curriculum of this wide range of programmes because they are all based on occupational standards that they define. This should provide confidence that curricula are keeping pace with industry needs (if standards are refreshed regularly) and help define clear progression routes from lower to higher skills, including a pathway to university-level education. In addition, higher-level apprenticeships are likely to carry a higher status than those at a lower level and have the benefit of enhancing the apprenticeship brand. Apprenticeships are likely to be recognized in society as an effective way to gain digital skills.

The risk in moving in this direction is that the apprenticeship brand may become diluted, leading to confusion about the purpose and target audience for apprenticeships and creating tensions about priorities for funding. Chapter 4 describes how, in England, this has been exacerbated by the introduction of an apprenticeship levy that has led to unintended consequences, where, for example, middle managers can be labelled as apprentices to undertake leadership programmes.

India has also introduced considerable flexibility into its apprenticeship system by introducing optional trades defined by employers. Australia has explored higher- and degree-level apprenticeships with a growing sense that apprenticeships systems will lose their relevance if they do not adapt to meet the skills demands of the knowledge economy.

The alternative is the Singapore model, which retains quality apprenticeships model for the initial training of young people along with a wide range of other employer and individual digital skills development programmes aimed at adult upskilling and business development. Many of these programmes have a work-based element and range from digital literacy for all to masters level programmes in critical digital skills areas. They are packaged under a single brand and delivered through an online portal that maximizes visibility and access. The Singapore model has allowed the government to build a comprehensive and flexible programme for skills development to support digitalization where apprenticeship has a place but is not the whole solution.

Essential recommendations

At the policy level, there is a choice to be made about the positioning of apprenticeships. There is no single right answer, but governments need to consider the following points.

▶ Engage business and other key stakeholders to shape a clear strategy for digital skills development in which role of apprenticeships is clearly located.

▶ Strengthen anticipation of new skills and improve the matching of skills demand and supply by using labour market information and analysis to track the speed of digitalization and its effect on jobs and skills, including hybridization and emergence of new occupations.

▶ Use digital literacy, user skills and professional IT (digital maker) skills to allow a clear focus on the hierarchy, range and level of proficiency of the skills required.

▶ Include adult skills updating (mainly for user skills) and higher-level skills development (mainly for maker skills) as important components of the strategy

Radical recommendations

▶ Use big data rather than conventional labour market information surveys to get real-time information on the digital skills in demand in the labour market and whether these are being fulfilled.

▶ Create partnerships between business, universities and TVET institutions to explore the need for higher- and degree-level apprenticeships in IT professional (digital maker) skills and encourage higher-skills apprenticeship pilots

▶ Use apprenticeships to support digital user skills updating in the workforce, including rethinking the concept of on- and off-the-job training to support more flexible and bite-sized apprenticeships based on modular standards. A blended learning model that includes appropriate student mentoring and support to avoid the risks associated with online bite-sized learning should be used.

▶ Enhance this apprenticeship offer by presenting, under a single digital skills umbrella, a wider range of work-based digital user skills development programmes for adults that support digital literacy, user skills and professional skills development. They could, for example, be presented together under a single "brand" and through an internet portal (as in Singapore and India). These programmes should draw on key aspects of apprenticeships, including being competence-based and with a work-based learning focus, but be repackaged in a modular form as mini apprenticeships

▶ 5.2 Curriculum, teaching and accreditation

The curriculum challenge is about keeping apprenticeships relevant and up to date in the face of rapid technological and occupational changes and designing them to allow workers to access continuous adaptation and skills development through their lives. The accreditation challenge is about providing appropriate apprenticeship accreditation for digital skills, including making considerations about the future importance of vendor-specific accreditations and digital badging. The teaching challenge is about supporting training institutions to teach digital skills successfully when staff may themselves lack the necessary digital skills, recent workplace exposure, or adequate facilities and equipment. It is about matching strategy and policy intentions with the high-quality delivery of digital apprenticeships on the ground.

Issues include how to attract people with high-level digital skills to work in an educational environment when they could earn more in private industry and how to upgrade the skills of existing college staff so that they can confidently teach digital skills. Also, it is important to consider the question of how to upgrade equipment and facilities so that students experience the same software and technology that they will find in the workplace when maintaining adequate internet capacity and access to computers is expensive and equipment rapidly becomes outdated.

Essential recommendations

Digital technologies change rapidly, creating challenges in keeping standards and curricula up to date, requiring systems to refresh more quickly and to be agile in adapting to hybridization as the lines between occupations blur and new occupations emerge. The ways forward include the following.

▶ Bring together leading employers from IT, telecommunications and other key sectors affected by digitalization, supported by their sector trade or skills organizations such as SSCs, to explore the skills impact of digitalization, map key digital occupations and assess how apprenticeships in each sector need to be adapted to support digitalization.

▶ Ensure occupational standards development work is being genuinely led by expert practitioners from the industry who are at the cutting-edge of digital skills development.

▶ Develop standards for digital occupations that fit together within an overall occupational map, with clearly defined progression pathways and the flexibility to move from vocational education and apprenticeships to higher education.

▶ Strengthen existing apprenticeships for young people by adding digital literacy, digital user skills and a wider package of cognitive and social skills development to all occupational frameworks, which are appropriately contextualized by occupation and level. Develop national digital literacy standards to support this.

▶ Consider how standards could be modularized, like in Australia, so that they can be used more flexibly for skills updating but ensure these are developed against an overall occupational map to avoid uncontrolled fragmentation of the standards system.

▶ Bring accreditation bodies together to work through how to overcome the risk of friction between the TVET and the higher education system in accrediting higher- and degree-level digital apprenticeships. TVET accreditation systems typically use competence standards at their core and are accredited nationally, while universities, in for example the UK and Australia, have their own awarding powers and are not competence-based. Programmes that lie at the boundary can raise accreditation issues as illustrated in the Australian example described earlier in this report.

▶ Retain a minimum proportion of off-the-job training (typically 20 per cent) to ensure people have time to build underpinning technical knowledge and a wider understanding of how their work contributes to a knowledge-based society. There may be an argument that this should not apply to short programmes for adults to update their skills in the workplace, although that raises questions about whether these programmes can be considered apprenticeships.

▶ Continue to develop the use of online and blended learning. This has become a normal way to deliver off-the-job learning during the COVID-19 pandemic and should be further developed to complement classroom-based learning.

▶ Explore more flexible accreditation processes in the workplace, including the use of software to track and record student progress, smartphone video evidence to show competence, online interviews with assessors, and recording of end test evidence.

▶ Support training institutions to recruit, train, develop and retain staff with the necessary depth of digital skills to be industry credible and with the ability to acquire excellent teaching and mentoring skills.

▶ Prioritize staff development in training institutions and companies. Use practice observation, individual action planning and mentoring to build teaching, apprenticeship monitoring, and assessment skills. Support staff should be able to use digital technologies in teaching, and regular industry exposure should be provided to ensure staff keep up to date with rapidly changing technologies.

▶ Establish regular self-assessment for training institutions for the quality of their digital apprenticeships.

▶ Equip training institutions with industry standard facilities, equipment and software along with fast broadband and access to laptops/devices, which should updated on a regular basis. Government capital grants should be supplemented with private partnership support from vendors and the local business community.

Radical recommendations

▶ Consider the development of specialist higher- and degree-level apprenticeships in, for example, programming, cyber security, AI and data analysis, to provide a progression pathway for TVET students to become IT professionals and to enhance the perceived value of work-based training in the tech sector.

▶ Develop international standards for digital literacy and user skills on a modular basis and regularly update them as a resource for high- and lower-income countries to quickly enhance their apprenticeship programmes with digital content.

▶ Allow the flexible combination of units within overall competence-based occupational standards to ensure that the standards reflect the hybridization of work and the "blurring of lines" between different occupations.

▶ Create partnerships between universities and employers to pilot the development of degree-level (digital maker) apprenticeships. Ensure these are fully integrated with coherence between the workplace and university components, rather than simply adding a placement to an existing IT degree.

▶ Consider how micro-credentials or badges could be incorporated within the framework of assessment for apprenticeships in digital skills to reward the completion of modules or units of learning. International standards should be established by asking global tech companies to work together to shape the orderly development of micro-credentials, allowing a comparison of depth and level and aiding the transferability of skills.

▶ Consider building greater flexibility into institutional pay structures to attract staff with credible industry digital skills.

▶ Develop apprenticeship quality assurance and inspections that regularly assess the maturity and effectiveness of apprenticeships provision, including the quality of on-the-job supervision and mentoring and off-the-job teaching and learning

▶ 5.3 Inclusion

The inclusion challenge is about supporting access to apprenticeships so that no one is left behind by digitalization. The importance of equality, diversity and inclusion runs through all the challenges and recommendations outlined here, from policy and strategy to curriculum, financial incentives and sustainability. Inclusion is a fundamental driving force behind quality apprenticeship delivery and must remain central as apprenticeships adapt to the needs of digitalization and knowledge-based economies. The recommendations below are drawn from specific good practice ideas in the case study countries that are not highlighted elsewhere.

Essential recommendations

▶ Adopt a "no one left behind" policy when tailoring apprenticeships to meet the challenge of digitalization.

▶ Recognize the persistent gender imbalance in IT occupations, influence young people from an early age to build digital literacy including understanding the opportunities provided by work in digital occupations and how attractive these can be for women.

▶ Provide positive action incentives to meet the additional costs for employers of taking on apprentices with disabilities and learning difficulties.

More radical recommendations

▶ Partner with Microsoft, Google and leading vendors to drive scale into equality, diversity and inclusion actions as NASSCOM has done in India.

▶ Create a national online portal of skills opportunities (including apprenticeships) and career development tools, as Singapore has done, to raise awareness of opportunities for all citizens to "develop their fullest potential throughout life, regardless of their starting points" (SkillsFuture n.d.)

▶ Design more flexible apprenticeship models including modularized skillsets to help people who are unable to commit to full-time apprenticeship study to gain user skills.

▶ Engage the international tech industry to shape their global skills programmes to meet local needs and culture and seek their support to build greater scale into diversity initiatives.

▶ 5.4 Funding and delivery

Funding and delivery challenges are about meeting the cost of adapting and delivering apprenticeships to support the needs of digital and knowledge-based economies and providing the necessary ways to engage employers and support individuals. The specific issues include:

▶ sharing the cost of digital skills programme design and delivery equitably to avoid placing an excessive additional burden on public funds;

▶ supporting adult upskilling in digital skills while maintaining adequate levels of investment in initial apprenticeship training for young people; and

▶ considering the relative costs associated with different types and levels of apprenticeship.

Effective employer engagement is critical to success and primarily rests on the relationship between a training institution and its local employers in organizing and delivering a digital apprenticeship. Arrangements to sharing the burden of cost will be critical and typically will be set out in a contract between the employer, apprentice and training institute. Other issues may include providing help with recruitment, monitoring progress, mentoring and assessment. In particularly successful cases, skills partnerships can go further, with employers influencing curriculum design and providing technical support, facilities and work experience to college staff to keep them up to date. Centres of excellence in digital skills are a way of focussing resources and bringing powerful partnerships together to drive this agenda.

Essential recommendations

▶ Fund development projects to adapt, develop, pilot and support the implementation of apprenticeships to meet digital user and IT professional skills needs, including funding to support staff development, facilities and equipment.

▶ Set realistic targets for the expansion of digital skills apprenticeships, recognizing the relatively high cost of higher- and degree-level apprenticeships.

▶ Consider how to draw together government, donor and industry contributions into a sustainable public-private partnership model to support digital skills apprenticeship development.

▶ Develop employer incentives to achieve the scale and speed of digital skills apprenticeship uptake required, especially during the COVID-19 pandemic. Consider applying these incentives on a first-use basis to maximize the impact of public funding.

▶ Support the creation of SSCs and of links to existing employer bodies such as chambers of trade and commerce to coordinate the delivery of digital user skills apprenticeships in smaller companies.

▶ Lower-income countries may need to support individuals by providing stipends for learners where employers or master craftsmen are unable to contribute. Stipends may be important in supporting learner participation, but they shift the balance of responsibility for employment costs away from employers. Apprentices with digital skills are likely to be in high demand, and their employment costs should be met by employers from the earliest possible point.

Radical recommendations

▶ Consider using an industry an apprenticeship levy/grant model that targets investment in digital training and digital apprenticeships. Levies are effective in creating a sustainable resource pool that can be deployed to incentivize apprenticeship delivery. However, but as the example of the UK set out in previous chapters shows, they can have unintended consequences in terms of changing the balance of the programme between high and lower skills, affecting both the ratio of adults to young people and the balance between technical and managerial skills, as employers seek to recover levy funds rather than meeting the primary aims of the apprenticeship programme.

▶ Encourage the development of digital apprenticeship centres of excellence. These would be partnerships between quality training providers and employers to co-design and deliver digital literacy, user skills and high-level maker skills through apprenticeships that improve business performance and demonstrate the effectiveness of the apprenticeship system. These pilot centres of excellence could be new physical buildings in a single location, specializing in digital skills development, or they could build on existing high-quality training. They could possibly be networked together to share learning and build capacity and capability across the apprenticeship system. It should be possible for these centres to attract recognition and support from global tech companies as centres of excellence for digital skills.
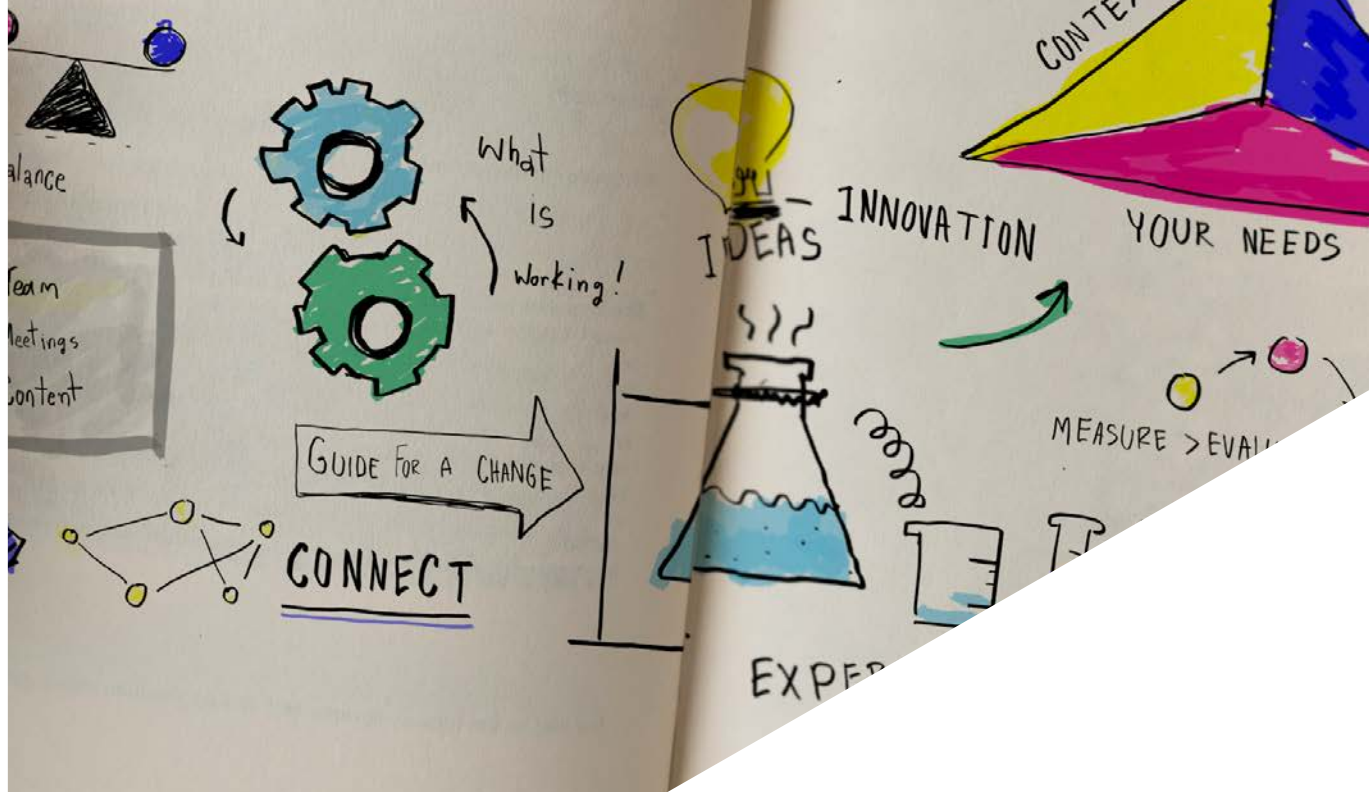
6 Case Study

▶ Case Study 1
Patterns of digital skills need in different sectors and occupations

The snapshots included here illustrate how digitalization is having a profound impact in three key sectors of the world's economy – healthcare, financial services[14] and manufacturing.

Financial services

This is a sector of economic importance in many economies that has been hugely disrupted by digitalization. The driver of transformation here is the rapid growth of external tech companies ("fintech") that bring in new e-enabled financial services to consumers and the use of AI to automate traditional bank mortgage and lending jobs, with online banking replacing banks on the high-street.

For example, financial services in the UK are a key driver of GDP growth and economic success. Severely impacted by the economic crash of 2008, technology (accelerated by COVID-19) has now driven further changes in customer demand for banking services. The UK is rapidly catching up with economies like the US and Finland, where cash has been replaced with electronic payments, shopping has gone online, cheques are rapidly disappearing, and banking is done through mobile apps connected to accounts software and taxes are paid electronically to the government. In addition, disruptors such as Revolut are grabbing the market share of traditional banks by offering free international transfer of funds.

Countries with an important financial services industry, like the Bahamas, are facing very similar issues. They need to provide technologically sophisticated services to their international clients and also support Bahamian citizens who predominantly still prefer cash and cheques (Donnell 2021) despite the growth of services like PayPal and other electronic payments. They may also live on a large group of family islands, often far removed from traditional banking facilities. In response, the government introduced the sand dollar in 2020, which is claimed to be the first central bank digital currency in the world and is part of a wider payments system modernization programme.

Occupations which are likely to remain stable include cybersecurity specialists, wealth managers, data specialists, innovation officers and specialists in the legal, compliance and risk areas of financial services. Digital and interpersonal skills will continue to be intertwined, and these roles will be vital to how bank's structure their workforce.

Skills shortages are a problem in regulatory and compliance roles, particularly for software, analytics and regulatory and compliance specialists. The shortage of coding and software skills is a particular concern. These skills shortages are predicted to worsen as the business areas of regulation and compliance become increasingly analytical.

The existing workforce may not have the digital skillsets needed for transformational change, and it has proved difficult in the UK as well to attract top digital skills in competition with Facebook and Google, when these companies appear to offer graduates and early career professionals a more attractive and flexible working environment than traditional banking.

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13 The analyses in these case studies is drawn from Kispeter 2018.

Healthcare

This is a large and complex sector and is both public and private. The drivers of transformation are population ageing, technology changes, advances in treatments, and growing patient expectations. The growth of digitalization includes telecare, assistive technologies and telehealth (accelerated by COVID-19), complex technology for patient scanning, surgery, and life support. The development of electronic record systems is also a huge challenge.

There are four key occupations – nurse, auxiliary, doctor and care worker – that have a wide range of other non-clinical and managerial roles. New para-professional roles are emerging to fill gaps between traditional professional roles in the sector. There is an argument that all nurses now need to be "e-nurses", given their requirement to interact with IT systems and medical technology.

System-wide digital transformation programmes recognize that staff need to be digitally willing and able. The issues they face include:

▶ uneven levels of digital literacy in frontline staff and their lack of time to engage with digitization

▶ patients struggling to use assistive technologies

▶ a lack of skills in health analytics

▶ Despite numerous IT systems, the staff still rely on paper. System demands are seen to take time away from patient care.

In the UK and across much of the world, COVID-19 has had a huge impact. Apprenticeships were put on hold to allow all staff to focus directly on treating those affected by the pandemic, and final assessments were delayed because of a lack of access to hospital and care settings.

Manufacturing

The "application of ICT is … reshaping modern manufacturing [Ezell 2018], … changing how products are designed, fabricated, used, operated and serviced …, just as it's transforming the operations, processes, and energy footprint of factories and the management of manufacturing supply chains." However, the manufacturing sector has continued to rapidly adapt through the COVID period (Make UK and Sage 2020), rapidly shifting to online working, increasing the use of big data, robotics, analytics, AI and automation. This report calls for a "tidal surge of digital skills" to counteract the lack of digital skills training by a third of manufacturing companies and concerns about "vocational training not keeping up with the skills they need".

The term Industry 4.0 was coined in Germany, to describe the convergence of digital technologies and manufacturing, through the vertical integration of smart machines, products, and production resources into flexible manufacturing systems, also known as "smart manufacturing" or the Industrial Internet of Things (IIoT). The application of IoT is projected to generate US\$5.5 to US\$12.6 trillion of value globally by 2030 (Chui, Collins and Patel 2021) in four primary forms: 1) operational efficiency; 2) predictive and preventative maintenance; 3) supply chain management; and 4) inventories and logistics.

Despite this promise, a 2015 survey of 4,500 German small and medium enterprise (SMEs) manufacturers found that less than 20 percent had heard of Industry 4.0 and a June 2017 survey of 250 U.S. SME manufacturers found 77 percent reporting that they still had no plans to implement IIoT. SME manufacturers said that the primary reasons were a lack of awareness, internal expertise, and workforce

skills. Many manufacturers (especially SMEs) don't know how to deploy digital technologies and organizational and cultural factors are often more difficult to address than the technological ones.

The skills implications for manufacturing, according to Deloitte (2020), include creating integrated flexible and cross-disciplinary teams that can bridge the divide between operations and IT functions in a business. Skillsets need to include engineering, data management and analytics, digital marketing, software development, human interface design, supply chain management and IT. They argue there will need to be a culture of constant learning and support to help employees adapt.

A recent international study of skills for high-value manufacturing (High Value Manufacturing Catapult 2020) has identified the following factors that support effective skills development.

▶ Create a strong link between innovation and skills development and the importance of centres of innovation in supporting workforce development, especially by defining standards and curriculum.

▶ Create more modular and flexible training courses that can be used to upskill and reskill the existing workforce. An example of this in practice is SimTech's work with SkillsFuture in Singapore to develop manufacturing content for the Future Series of modular courses. These can be used on a stand-alone basis or be plugged into apprenticeships and full-time courses.

▶ Use "learning factories" to simulate common manufacturing system scenarios. In the German state of Baden-Württemberg, some 40 "smart factories" are now in place across the network of Technical Schools. Also, the Institute for Technical Education in Singapore is developing a manufacturing curriculum around a learning factory with a strong focus on supporting culture change in small businesses.

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