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Understanding the impact of artificial intelligence on skills development

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SHORT SUMMARY

Navigating the era of AI

The era of artificial intelligence is young in years but advanced in impact. Intermediate skill jobs as we know them are fast disappearing as their tasks are systematically automated, and individuals are increasingly likely to encounter AI technology in their everyday lives. In fact, fifty percent of organizations worldwide report using some form of AI in their operations.

It is clear that AI has broad implications for the whole of humanity, and therefore on the education and training institutions that equip lifelong learners with the skills to navigate both work and society. A wide range of institutions and other stakeholders have risen to the challenge through research and innovative programmes, paving the way for a better understanding of AI's potential – and its pitfalls.

50%

of organizations worldwide **report using some form of AI** in their operations.

This paper synthesizes research on current trends, programmes, policies and uses of AI related to technical and vocational education and training across six continents, covering developing and developed contexts, as a resource for stakeholders invested in the future of intermediate-level workers and TVET. Lecturers, students, administrators, policymakers, programme implementers and lifelong learners are invited to examine current practices, opportunities and challenges raised by AI, and recommendations to build a future-ready education and training system.

"Since wars begin in the minds of men and women it is in the minds of men and women that the defences of peace must be constructed"

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Glossary

A/IS	Autonomous and Intelligent Systems
AGI	Artificial General Intelligence
AI	Artificial Intelligence
AI HLEG	High-level Expert Group on Artificial Intelligence of the European Commission
BIBB	Federal Institute for Vocational Education and Training (Germany)
CEDEFOP	Centre Européen pour le Développement de la Formation Professionnelle (European Centre for the Development of Vocational Training)
COMEST	UNESCO Committee on the Ethics of Scientific Knowledge and Technology
CORE	Centres of Research Excellence
EU	European Commission
HITSA	Hariduse Infotehnoloogia Sihtasutuse (the Education Information Technology Foundation)
ICT	Information and Communications Technology
ICTAI	International Centre for Transformational Artificial Intelligence
IEEE	The Institute of Electrical and Electronics Engineers
ILO	International Labour Organization
IoT	Internet of Things
ITU	International Telecommunication Union
NCVER	National Centre for Vocational Education Research (Australia)
NITI	National Institution for Transforming India
PC	Personal Computer
STEM	Science, Technology, Engineering and Mathematics
TVET	Technical and Vocational Education and Training
UN	United Nations
UNESCO	United Nations Education, Scientific and Cultural Organization
UTHM	Universiti Tun Hussein Onn Malaysia

Introduction

Digitalization and artificial intelligence (AI) are changing the way we work, live, communicate, learn and play. Whether they are aware of it or not, individuals are increasingly encountering advanced technologies such as AI in their everyday lives, in exchanges as diverse as applying for a loan and scrolling through social media, some of which may have a profound impact on their lives. Two decades into the twenty-first century, many occupations are being impacted by human creativity and ingenuity that are making it increasingly possible to capture value from new technologies. More and more national policies are focusing on AI, which is being incorporated into and impacting industrial and agricultural processes, services, value chains and the organization of workplaces. AI has the potential to improve people's lives, but it also raises a number of important policy, ethical and social issues, including job creation and job obsolescence. It represents a source of social and political tension, and risks exacerbating inequalities within and across countries.

AI is also transforming labour markets. A report by the McKinsey Global Institute suggested that about half the work tasks performed by people could be automated through current technology by 2055 (Manyika et al., 2017), thereby intensifying the significant trend towards higher-skill jobs. Moreover, a growing body of evidence concludes that influences such as technology and globalization are 'polarizing' the workforce into high-skilled and low-skilled jobs or, alternatively, 'hollowing out' demand for intermediate-level skills (Autor 2010; Bárány & Siegel, 2015; Brown, 2016; Goos, Manning & Salomons, 2014). Workers with intermediate skills are at particular risk because of the routine nature of the tasks they often perform and the fact that the technologies that can replace them, such as AI and robotics, can create considerable cost savings for employers. However, an important caveat is that this refers to *intermediate skills as we currently know them*. Analyses conducted by occupation rather than wage percentile reveal the persistence of intermediate occupations, thereby highlighting 'the changing nature of intermediate jobs' (McIntosh, 2013: 41). Therefore, while the skills needed by the labour market may be changing, intermediate-level education such as technical and vocational education and training (TVET) remains far from obsolete in the digital age.

In this dynamic context, the key to guaranteeing an inclusive society lies in the ability to accurately identify and even predict shifts in skills requirements and systemic 'pressure points', such as demographics with limited access and opportunities, and in providing timely responses along the education value chain. While a number of policy responses have so far focused on developing or attracting the limited pool of high-level talent in AI, there is a need for education and training institutions, particularly those that focus on intermediate skills, to acknowledge and embrace their share of the transformation effort.

TABLE 1 **Descriptions of ILO skill levels 2 and 3**

	SKILL LEVEL 2	SKILL LEVEL 3
Description	These occupations generally require relatively advanced literacy and numeracy skills for the purposes of reading instruction manuals, recording information or events and performing routine calculations.	These typically involve the performance of complex, practical tasks that require extensive knowledge of a specific field. These occupations require a high level of literacy and numeracy and well-developed interpersonal skills.
Examples of associated tasks	Operating machinery, driving vehicles, maintenance and repair of electrical or mechanical equipment, handling and storage of information, etc.	Financial and/or personnel management, customer relations, installation and repair of technical or mechanical systems, medical testing, etc.
Typical educational requirements	Completion of the first stage of secondary education, with many also requiring specialized vocational and on-the-job training.	Secondary education and 1-3 years of study at a higher education institution and/or continuous on-the-job training or experience.
Examples	Butchers, secretaries, police officers, hairdressers, etc.	Shop managers, technicians, legal secretaries, etc.

Defining intermediate skills

The definitions of 'intermediate skills' and 'intermediate occupations' vary. For the purposes of this paper, they refer to the jobs classified by the International Labour Organization (ILO) as skill level 2 and skill level 3[1]:

The purpose and structure of the paper

This paper uses desktop research, policy analysis, case studies, sector reviews and semi-structured interviews with education and training practitioners to examine AI and the ways in which AI is expected to continue changing economies and labour markets. The work highlights how intermediate-level work will be further affected and how education and training institutions can harness new technological and procedural developments to improve their own responsiveness to the demands of the labour market and society. It is hoped that this work will be of value to policymakers, TVET administrators and practitioners and the international community invested in skills development.

The first section of the paper, titled 'An overview of AI and its roles', serves as a primer for stakeholders who may not be particularly familiar with the technical and conceptual aspects of AI and how it functions or its role in labour market shifts and economic development. This section first explores what AI is – and what it is not – through a brief explanation of fundamental concepts related to AI. The section then describes the role of intermediate skills in the changing labour market of the AI era.

The second section, titled 'An exploration of current AI education and training practices', uses the knowledge outlined in the first section as a springboard to engage in discussions framed by some of the key recommendations of the *Beijing Consensus on Artificial Intelligence and Education*, namely: 1) Planning and governance for the AI era; 2) Ethical and inclusive use of AI; 3) Values and skills for the AI era; 4) Empowerment of teaching and learning through AI; and 5) Creation of lifelong learning opportunities through AI. The consensus view on each topic is followed by a discussion on current practices, challenges and relevant examples of AI applied to education by drawing on both original research and the considerable body of literature on AI in education that already exists.

The final section, titled 'AI and the future of TVET', provides reflections on the findings of this paper and the way forward, and offers recommendations for the governance of AI and the integration of AI into TVET institutions.

1 International Labour Organization (2012). *International Standard Classification of Occupations: ISCO-08 Volume 1*. Geneva: ILO. The ILO's skill levels are based on the nature of the work performed, the level of formal education and the amount of informal or on-the-job training and experience required for competent performance.

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To develop a sense of the potential contribution of AI to education and training, it is useful to outline the possibilities inherent in the wide range of technologies that fall into the AI category and to draw distinctions between AI and related fields, such as robotics, and the broader scope of information and communications technology.

This section provides examples of the disruptive force of AI in other sectors, such as agriculture and health, and briefly discusses the types of AI that are prevalent in everyday life. It then explores the influence of AI on economies, labour, and education and training, with a particular emphasis on intermediate skills.

SECTION 1
AN OVERVIEW OF AI AND ITS ROLES

AI concepts and overview

AI can bring changes on all fronts, whether social from detecting emotions or infrastructure management for example, where traffic-light networks can be optimized using real-time traffic camera data and Internet of Things sensors to maximize vehicle throughput. AI can be used to schedule predictive maintenance of public transportation systems, such as metros and public infrastructure, to identify potentially malfunctioning components. In economic and social sector management AI can be used to identify tax fraud using alternative data such as browsing data, retail data, or payments history.

Interview with an academic, Polytechnics Mauritius

AI is not a new phenomenon. Much of the theory that underpins AI was developed by computer scientists such as Alan Turing, Marvin Minsky and John McCarthy as far back as seventy years ago, and AI has been used for some time now in industries such as finance and in STEM fields. What has changed dramatically over the past decade is access, speed and availability. In his 2011 essay 'Why software is eating the world', Marc Andreessen explains that 'six decades into the computer revolution, four decades since the invention of the microprocessor, and two decades into the rise of the modern Internet, all of the technology required to transform industries through software finally works and can be widely delivered at global scale' – and is also affordable for many.

Current iterations of AI are largely industry-driven, created with the primary goals of enabling new businesses and improving on the efficiency of existing fields; broad investments have been made in fields such as healthcare, finance, marketing, agriculture, urban planning, education, services and security (CBInsights, 2018). AI use cases include improved crop yields through real-time advisories on pests, soil, weather and crop prices; targeted advertising and preference-based browsing; inventory, supply chain and delivery management; predictive maintenance of equipment and/or infrastructure; automation of administrative tasks and records management; customer service chatbots; fraud analytics and cybersecurity applications. AI has outperformed a military fighter pilot (Baraniuk, 2016) and accurately detected glaucoma (Nvidia, 2018), and in 2017 the AI programme AlphaZero took the world computer chess champion title after teaching itself the game in four hours (Gibbs, 2017). In 2020, the AI programme AlphaFold predicted a protein's 3D structure and successfully applied AI to solve a complex grand challenge that biologists had been working on for over fifty years (Sample, 2020). Currently, in 2021, an AI chatbot called iTrack Skills, which was developed to track TVET graduates, is being piloted in three countries (Montenegro, Tanzania & Bangladesh)[2].

AI offers such versatility because AI itself is versatile. As noted by Calo (2017), there is no universal consensus concerning the standard definition of AI and what it constitutes. AI actually refers to a variety of techniques that vary in complexity and share a common outcome: the imitation of human cognition or decision-making.

Most recent advances in AI have been achieved by applying machine learning to very large datasets in different ways (Brookfield Institute, 2018). AI systems vary in complexity depending on the task to be completed and rely on varying degrees of human input to their parameters. At one end of this spectrum is supervised learning, in which input and output parameters are labelled and determined by humans. In unsupervised learning, inputs are still labelled by humans, but the algorithm groups items according to common characteristics, a technique often used in targeted advertising. At the other end of the spectrum is reinforcement learning, in which an algorithm and its decisions are improved through various approaches to maximize a 'reward' (for example, returns on an

2 https://www.ilo.org/budapest/whats-new/WCMS_735020/lang--en/index.htm

investment), and deep learning, a type of machine learning inspired by the neural connections in the human brain, whereby interconnected layers of software-based calculators known as 'neurons' form a 'neural network' that processes sequential layers or loops of increasingly complex information. Neural networks can be convolutional or recurrent. Convolutional networks perform incremental analysis at increasing levels of complexity, and the output will differ at each level (as in image processing). Recurrent networks store information in context nodes, thus allowing them to 'learn' data sequences (as in predictive text) (McClelland, 2017).

AI is classified as having 'narrow intelligence', 'general intelligence' or 'super intelligence', depending on the extent to which it provides intelligent, subjective responses to input. So far, we have achieved only 'narrow' AI, which refers to AI that acts within a limited set of environments or parameters, although some technology can be applied to multiple contexts.

Artificial general intelligence (AGI) refers to the hypothetical ability to react appropriately in a wide range of environments to perform a wide range of tasks (Davidson, 2019; O'Carroll, 2017) or to perform any human task (Baggaley, 2017). The tests proposed to determine whether AI can be considered general involve evaluating whether a robot can successfully attend college and the Turing test (Turing, 1950), which analyses a machine or programme's ability to exhibit behaviour that is indistinguishable from that of humans. Two machines, Eugene Goostman and Cleverbot, are said to have passed the Turing test, although these claims have been disputed; Alphabet's Google Duplex apparently passed the test in 2018, with the caveat that the conversation was limited to making appointments. In short, AI technology has not yet achieved the Turing test milestone in any meaningful way. And while 90 per cent of experts surveyed in 2014 believed that AGI would be achieved by 2075, this would require significant breakthroughs in both processing power and machine learning techniques (Joby, 2020).

AI and economic growth and development

Historically, technological advances have led to a decline in some jobs and a rise in others (Furman, 2016). One viewpoint argues that AI will play a pivotal role in economic development and will effectively improve production and overall income. Research by Accenture suggests that AI has the potential to boost rates of profitability by an average of 38 per cent and will lead to an economic boost of US$14 trillion across sixteen industries in twelve economies by 2035 (Purdy & Daugherty, 2017). Furthermore, cloud-based AI initiatives such as TensorFlow provide open access to innovative and productivity-boosting technology (Access Partnership, 2018), a key driver of economic growth (Frontier Economics, 2018).

Neither governments nor industry are blind to the current and future influence of AI. The 2020 McKinsey Global Survey on AI[3] found that half of respondents reported the use of AI in their organizations, and private equity investment in AI doubled between 2016 and 2017 to more than 16 billion USD (OECD, 2018). The government of China estimates that 26 per cent of its GDP in 2030 will be sourced from AI-related activities and businesses (Chinese State Council, 2018), while the United Kingdom Industrial Strategy anticipates that its GDP will be 10 per cent higher as a result of AI by that same year (United Kingdom, 2021; United Kingdom, 2018).

Disruptive technologies are nothing new to humankind, and pundits have been intrigued by Schumpeter's concept of creative destruction for decades. In 1966, for example, the US National Commission on Technology, Automation and Economic Progress concluded that technology may eliminate or replace jobs, but not work as a whole, and that technological changes have caused and will continue to cause displacement throughout the economy (United States, 1966). The conclusions of the study have proved correct. For example, the introduction of the personal computer (PC) led to the creation of 15.8 million net new jobs in the United States in the last forty years, even after accounting for jobs lost due to displacement. More importantly, over 90 per cent of these jobs are 'in occupations that use the PC but in other industries, such as call centre representatives, financial analysts and inventory managers' (Lund & Manyika, 2017).

The McKinsey Global Institute estimates that, between investment and productivity growth, full employment could be achieved if disrupted workers can be re-employed within one year; in a more likely scenario, however, growth trends would vary, with semi-skilled work opportunities increasing in developing nations and middle- and low-skilled labour demands decreasing in more developed economies, and the income gap would widen (Manyika et al., 2017). As noted by Furman (2016), there is little reason to believe the net effects of AI transformation will yield dramatically different results from previous technological advances, which have increased wage inequalities, particularly among workers with high school diplomas, who saw their relative wages fall from over 80 per cent of those with college degrees to less than 60 per cent. In addition, it should also be noted that historical trends have typically shown displacement from middle-skill and low-skill work to higher-skill work (Brown, 2016; OECD, 2016; Pew Research Centre, 2016). Therefore, if these trends continue, semi-skilled labour is likely to be the hardest hit.

3 https://www.mckinsey.com/business-functions/mckinsey-analytics/our-insights/global-survey-the-state-of-ai-in-2020

The influence of AI on the labour market

> ***There is a gap between the skills profile of the current labour force and the growing demand for more highly skilled workers. Modelling by Australia's CSIRO indicates that the most needed future skills in the economy relate to science, technology design, engineering, mathematics, programming, systems analysis, critical thinking and computer use skills; and of these, it is technology design skills that are represented in the jobs with the greatest employment growth potential, followed by mathematics, computer use and critical thinking skills.***
>
> *Interview with an NCVER official, Australia*

While AI interactions with economies and systems are complex, the principal means by which AI is likely to have a direct effect on employed individuals are replacement of human workers, combinations of AI-enabled devices, systems and intelligent robots, and augmentation of human performance at work ('AI plus X' models) (NITI Aayog, 2018). According to Brynjolfsson et al. (2018: 46-47), 'few (if any) jobs can be fully automated using ML [machine learning]. Machine learning technology can transform many jobs in the economy, but full automation will be less significant than the reengineering of processes and the reorganization of tasks', which would suggest that the integration of AI into tasks is likely to be the most prominent outcome of the current wave of digital transformation of 60 per cent of occupations could be automated.

In a political, social and consumer vacuum, the formula for determining the likelihood of job replacement would be simple: if the technology available could match human behaviour and operate at a lower cost-per-product ratio, the job would be automated. In such a scenario, the higher the amount of routine work, or work that requires predictable engagements and decision-making patterns, the higher the risk of the job being automated. However, the factors determining the likelihood of replacement are complex and involve legal mandates, consumer preferences and social and political pressure. For example, while it may now be technically possible for AI to accurately detect a range of health concerns, many effective prescriptions and treatment options can be obtained legally only from trained, licensed healthcare professionals. So while doctors may use AI as a diagnostic tool, i.e. 'pocket diagnosis', AI is unlikely to replace medical professionals unless there are significant changes to regulatory frameworks.

Examples of jobs with a significant risk of automation include transcriptionists, delivery drivers, records technicians, personal assistants or secretaries and factory floor workers. This automation may, in turn, give rise to new job opportunities related to the tasks undertaken by machines, but the support jobs created will often require more advanced training, preparation and skills such as computer programming and robot maintenance (CBInsights, 2018), thus leading to a further shift in the workforce towards higher-skill occupations, a trend observed by the Pew Research Centre (2016).

However, 'AI plus X' models (the use of AI to augment human performance at work) are likely to have the reverse effect. In the case of some higher-skill occupations such as medical professionals, the introduction of AI may lead to the consolidation or expansion of portfolios and reduced reliance on specialists. Through a combination of 3D printing and AI technology, for example, the activities of an orthotist or a prosthetist could feasibly be undertaken by a medical professional and a physical therapist together. In other cases, the introduction of AI will serve primarily to increase profits or profit margins, such as some predictive AI applications in the agricultural sector that may enable farmers with low or moderate skills to increase their yields and productivity. In some cases, the application of AI will enable lower-skilled individuals to enter the workforce by developing new skills, either through direct training provided by companies such as Sama, which hires low-income workers and trains them for digital work such as image capture and annotation (NITI Aayog, 2018), or by enabling workers with lower skills to achieve the same outcomes as their more skilled counterparts through the use of AI, such as AI-assisted loan decisions in the finance sector (Merlynn Technologies, N.D.).

AI and intermediate skills

While many discussions about AI revolve around strategies to combat the skills shortage in high-skilled jobs, discussions about the impact of digitalization on medium- and low-skilled jobs remain limited. In reality, however, the labour market is gradually polarizing between high- and low-skilled jobs (PEW Research Centre, 2016). There is a tendency towards, on the one hand, the 'hollowing-out' of skills and, on the other, demand for new skills among workers with intermediate skills. The transformation of middle-level tasks will consist of two dimensions. Firstly, repetitive tasks are likely to be automated. This trend is evident in middle-skill jobs, whose routine-oriented work and predictable environment can easily be replicated by machines.

Secondly, mid-level workforce skills will be transformed to include digital and transversal skills. While there is significant risk of automation in the developed world, some analyses suggest that the risk is even higher in parts of the developing world due to the higher degree of routine tasks such as sorting and tracking (Egaña del Sol & Joyce, 2020).

Eighty-two per cent of middle-skill jobs already require digital skills, which are associated with higher pay and greater opportunities for career advancement. Accordingly, digital skills serve three key functions for middle-skill job seekers:

- They provide access to the market for middle-skill jobs. In areas such as clerical work, customer service and business management, the demand for digital skills in middle-skill job seekers lies almost entirely in productivity software[4]. In fact, more than one-third (36 per cent) of middle-skill jobs are occupations whose only requirements in terms of digital skills relate to productivity software, while advanced positions demand more technical skill sets such as the use of CRM and digital design software. Spreadsheet and word processing skills remain the baseline for digital skills, with 78 per cent of middle-skill jobs calling for these as a minimum.
- They offer career advancement in lieu of advanced education. In retail, construction, production and maintenance, the ability to use productivity software is a prerequisite for advancement.
- They define a set of domain-specific competencies for specialized roles. Most of these are healthcare jobs such as health technician roles that rely on specific digital knowledge but are often entry-level jobs.

Non-digitally intensive middle-skill jobs are currently clustered in transport, construction, and installation and repair services. In other words, digital skills have become the minimum entry point for middle-skill jobs in most other sectors. As AI continues to permeate the labour market, similar shifts are expected to occur, with the gradual integration of some AI-related skills into nearly all occupations.

TVET systems across the world must therefore adopt a new approach to the changing landscape of middle-skill jobs and to equip the workforce with digital and transversal skills. Transversal skills can be applied to a wide range of life and work settings and include critical thinking, communication, and financial and media literacy. These skill sets enable workers to adapt to changes and identify and exploit career pathways and opportunities, an important consideration given that individuals are now expected to learn marketable new skills throughout life. Career progression planning will represent a central challenge for some countries over the next decade and beyond, particularly as public funding for job training programmes is falling in many countries, even as industry-sponsored training is on the rise (ManpowerGroup, 2018).

According to UNESCO (2016), TVET forms part of a lifelong learning pathway; it can take place at secondary, post-secondary and tertiary levels and includes work-based and continuing education and professional development. TVET therefore addresses a wide range of skilling needs. In nearly all countries, TVET systems play a central role in meeting the demand for low- and intermediate-level skills, although there are large variations across and often within countries with respect to the governance, funding, delivery, location and experience of TVET.

The packaging and timing of VET offerings need to be re-evaluated to engender flexibility and a focus on the new skills required for new forms of work… Agility can also be supported by better understanding the external environment. It is also now possible to obtain real-time data relating to job vacancies, skill requirements and changing employment patterns to inform decision-making and training content development.

Interview with an NCVER official, Australia

4 Productivity software refers to software that assists users in producing information such as documents, graphs and charts.

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SECTION 2
AN EXPLORATION OF CURRENT AI EDUCATION AND TRAINING PRACTICES

In view of the multifaceted developments in the prominence, provision and governance of AI in education, the *Beijing Consensus on Artificial Intelligence and Education* outlines a series of recommendations for the optimal use of AI in education and, more broadly, for the purposes of skills planning. This paper uses the key points of the consensus as a framework for further discussion and explores five interrelated areas covered by the consensus: planning and governance for the AI era; ethical and inclusive use of AI; values and skills for the AI era; empowerment of teaching and learning through AI; and creation of lifelong learning opportunities through AI.

This section examines the trends and challenges in each of these areas and summarizes the findings of the various types of research undertaken, including desktop research and synthesis, policy review, and interviews with TVET and higher education stakeholders. It presents examples of AI practices in each area that are currently being used or could be used in the future for the development of technical and vocational skills.

Planning and governance for the AI era

With respect to planning and governance, the *Beijing Consensus on Artificial Intelligence and Education* recommends the use of data and new data analysis methods to improve decision-making and planning processes, the identification of innovative new funding mechanisms, and the adoption of intersectoral and multistakeholder approaches to the planning and governance of AI in education.

While the degree of oversight and the level of integration of education and training institutions into government policies vary between and even within countries, an analysis of policy and government strategies very quickly clarifies the extent to which national development is seen to hinge on the capacity of education and training institutions to respond to emerging and evolving needs.

Between 2016 and 2018, at least twenty-six countries published their progress towards the development of AI policies (see the Appendix). This section outlines these early AI-related government policies and strategy documents, presents two examples of policies that take different approaches to AI governance and, lastly, reflects on the implications and opportunities of the key issues observed in policies for education and training institutions.

AI policy and strategy review

Governments must respond to both the conceptual challenges of AI and the very real impacts of AI on citizens and their lives and livelihoods (Brundage & Bryson, 2016). The core balancing act for governments involves creating environments to enable AI development and growth while simultaneously mitigating the risks posed by AI. Policymakers must consider whether machines should be entrusted to make decisions and, if so, when this should happen; whether the values implicit in decision-making reflect the values of society and broader social norms; and how to handle issues such as biased datasets and outputs, consumer and privacy protection, liability related to AI-induced harm, and cyberterrorism (Brookfield Institute, 2018). In addition, equal distribution of the benefits of AI represents a key social concern and constitutes a particular challenge in a context where most investment in AI is driven by the private sector and adoption of AI is led by business use cases related to direct financial profitability (CBInsights, 2018).

AI policy objectives and positioning

The objectives of AI policies and approaches differ across nations and are often linked to strategic or political priorities. For example, China, France and the UK are focusing on becoming primary locations for AI industry and their policies therefore revolve around developing national talent and creating the right conditions, including infrastructure. Competitive and rapidly developing economies such as South Korea, Singapore, Japan and China are focusing on the manufacture of new AI products and related concerns such as establishing intellectual property rights, carrying out global marketing and launching competitions or challenges to develop new applications and technologies. Malaysia, Mexico and India have positioned themselves primarily as providers within the AI value chain, based on the strategic advantage of low-cost labour. A few countries, notably Italy and the UAE, have integrated AI into government service delivery to improve efficiency. A final goal of AI policies is to set out strategic frameworks or priorities for industry, academia and other government initiatives with a view to aligning them with operational plans. This is most common in regional policy documents such as those published by the European Union and the Nordic-Baltic Region, but Sweden has also adopted this approach at a national level. The policy review revealed broad areas of interest, including education, quality of life, economic prosperity, national security, healthcare, energy, transport, city planning, robotics, mobility, information security, environment, agriculture and life sciences.

BOX 1 **Policy example – Sweden**

The Swedish Government published an overarching AI strategy in 2018, the *National Approach for Artificial Intelligence*[5]. Rather than outlining decisive government actions, the strategy provides key government objectives with which other stakeholders such as businesses, academic institutions and local governments should align. It identifies pillars across priority areas such as industrial development, healthcare, security and sustainable cities, including the redefinition and recreation of business and operational models; AI integration and uptake in businesses; access to data; and the development of AI skills and competencies among companies and the public. Nine strategic priorities encompass the areas of talent development, data access, research and ethical governance.

The priorities in terms of skills development include developing tertiary education in AI through collaborations between industry, the government and academia; investing in doctoral and postdoctoral AI students; expanding basic education to include computer science; encouraging lifelong learning and job mobility; and creating new, combined teaching and research positions, which would represent a viable strategy to mitigate the transition of AI academics into industry.

Governance concerns include 'innovative public administration' for AI development; a balance between business innovation and privacy, ethics and digital security; and the development of a state system to ensure that AI solutions address social challenges. Infrastructure and access to data for education, research and application-focused development projects remain a primary concern. The document further urges collaboration and a focus on the creation of drivers for AI investment and development.

AI governance structures

Policy initiatives concerning AI governance include the establishment of ministries or regulatory bodies to take direct responsibility for AI or, alternatively, the incorporation of AI responsibilities into existing ministries. For example, the AI Council in the UK draws on both academic and industry expertise, while China's 'national team' approach draws on industry expertise. Centralizing AI into specific departments or units entails a responsibility to upskill personnel and identify the expertise required, and advisory bodies could also include academic and/or industry experts. These measures help ensure that governments have the necessary AI capacity in a context where individuals with the required combination of public policy skills and AI expertise are thin on the ground (Gasser & Almeida, 2017; Kahn, 2018). Another approach designed to achieve the same goal, adopted as part of the UAE's AI strategy, focuses on AI training for government officials.

AI policy contributions to AI ethics

Although AI ethics was mentioned in most policies, only a few countries had begun meaningful policy discussions concerning the distribution of AI benefits and inclusive development by the end of 2018. For example, India engaged in policy discussions relating to equity and social benefits in a discussion paper subtitled *#AIforAll*, which argued that the 'the role of government becomes pivotal in ensuring large scale AI intervention' in industries such as education, in which the returns are not only delayed but may also be non-monetary (NITI Aayog, 2018: 22). Mexico's white paper *Towards an AI Strategy* includes a section on equity, particularly strategies designed to improve services for lower-wage earners. Most national policy documents do not include ethical guidelines, but mandate subsequent measures such as the development of councils or advisory boards on AI ethics, the revision of legal frameworks, research into the social impacts of AI and the drafting of additional, specific policies concerning ethics. The policy review found that internationally the most widespread focus is on enabling AI development and deployment, with limited responses or regulatory interventions planned to address the fallout of workplace disruption.

5 English summary: https://www.vinnova.se/contentassets/29cd313d690e4be3a8d861ad05a4ee48/vr_18_09.pdf

At least two sets of ethical guidelines have since emerged. The European Commission's *Ethics Guidelines for Trustworthy Artificial Intelligence* (AI HLEG, 2019) includes a section on both technology and the society in which it operates. With respect to technology, the guidelines call for privacy and data governance, transparency, accountability, and technical robustness and safety. They further cite human agency and oversight, AI for human empowerment and fundamental rights, diversity, non-discrimination, fairness in access, and societal and environmental well-being. Also in 2019, forty-two countries adopted the *OECD Principles on Artificial Intelligence* and, in doing so, agreed to uphold international standards aimed at robust, fair, safe and trustworthy AI. The principles begin by recommending inclusive growth and human-centred values and calling for 'responsible stewardship of trustworthy AI in pursuit of beneficial outcomes for people and the planet' (1.1), before addressing data concerns such as transparency, accountability and safety. The principles also recommend international cooperation, human capacity building and preparation for labour market transitions (OECD, 2019).

While these initiatives offer a framework and a starting point, the translation of these high-level guidelines and agreements into national policies and strategies is still very much in progress, which raises some concerns, since this policy vacuum has left the interpretation of ethics in AI largely up to industry, at least in the interim (Williams, 2019).

AI policy and skills development

In the publication *The Digitization of TVET and Skills Systems* (2020), the ILO and UNESCO argue that adapting to trends, such as complex and diverse work teams, constantly emerging technologies and the automation of routine tasks, requires that policies focus on anticipating skills needs and areas of deskilling through regular labour market scans using emerging technology; teaching transversal skills such as learning to learn; and improving the responsiveness of education to emerging trends, which requires close cooperation between education, research and industry.

While countries are embarking on all three of these recommendations, the policies reviewed focused primarily on skills development and the links between government, industry and academia, most often through the development of research centres, hubs or industrial parks equipped for AI development to pool the expertise of academia and industry. As crucially important links to AI talent development and workforce transformation, TVET institutions may be able to establish new links to industry, government and higher education through such initiatives if they are lucky enough to operate close to these hubs.

Another focal point of the policies is skills development across education levels. They feature primary and secondary education reforms through curricular changes, such as the piloted introduction of robotics and coding into South Africa's basic education curriculum (Malinga, 2020). The publication Australia's Tech Future calls for investments in infrastructure to enable greater access to online schooling with a view to improving equity in access.

BOX 2 **Policy example – India**

India is one of the countries with the strongest focus on AI for social inclusion. The discussion paper *National Strategy for Artificial Intelligence* (NITI Aayog, 2018) stresses the importance of using AI for social development and the active role that the government will have to play in terms of galvanizing investment in AI, incentivizing the use of AI and ensuring that adequate attention is paid to less monetarily profitable AI applications with robust social returns, particularly in sectors such as education and health. India's AI strategy proposes that work be carried out in two phases: the development of Centres for Research Excellence (COREs), which will then perform AI research whose applications will be developed and scaled through International Centres for Transformational AI (ICTAIs). Government investment, skills development and government planning will provide the foundations for scalable strategies that India hopes to introduce to the rest of the world.

The discussion paper notably positions government as the primary caretaker of the 'AI for universal benefit' approach and states that 'externalities from adoption of AI far outweigh the economic returns realized by private initiatives, and hence the role of government becomes pivotal in ensuring large scale AI intervention' (2018: 22).

Approaches to talent development in AI and related fields in tertiary education include the provision of bursaries or scholarships, the development of industry-academia training pathways and the creation of courses or even specialized AI education and training institutions. For example, South Korea's *National Strategy for Artificial Intelligence* provides funding for centres of excellence, and the UK's AI Sector Deal emphasizes the need for scholarships and bursaries for AI talent development. Continuing education also features in a smaller number of policies. Italy's *White Paper on Artificial Intelligence at the Service of Citizens* outlines the creation of training pathways for in-service workers, while Japan's Artificial Intelligence Technology Strategy calls for both investment and university engagement in retraining the current workforce. Talent acquisition is also a common theme throughout the policies of European countries, with measures such as specialized visas and incentives proposed to draw on the existing pool of AI talent.

BOX 3 **Policy example – China**

China has a robust strategy that addresses higher-level goals defined in relation to the economy and politics, including bringing China into line with its competitors by 2020; becoming a world leader in certain fields by 2025; and becoming the primary centre for AI innovation by 2030 and building a US$150 billion AI industry in the process. To achieve these goals, China advocates AI development in a number of areas. The first relates to skills planning and includes talent development strategies such as the creation of higher education courses and specialized universities. The second deals with infrastructure through the development of industrial hubs to deliver the connectivity, hardware and software required to attract businesses and give rise to innovation in the field. Finally, China's policy also sets out its ambition to lead the global governance of AI by, for example, swiftly defining and enacting laws, regulations and ethical standards in relation to AI. Soon after publishing its first strategy document in July 2017 (*New Generation Artificial Intelligence Development Plan*), the Chinese Government published its *Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry*, which outlines its stage-one priorities more clearly through action steps and the development of 'national teams', to include tech industry giants in partnership with the government. The tasks set out for the three-year period include the development of networked products such as robots, identification systems and vehicles; the development of neural network chips that can compete with Western products currently on the market; the adoption of intelligent manufacturing; the development of a US$2.1 billion technology park in Beijing; and investments in standard testing, training and skills, and, crucially, cybersecurity.

Ethical and inclusive use of AI

The consensus highlights the need to guarantee the equitable and inclusive use of AI. AI offers an opportunity to improve access to the most vulnerable groups, but care must be taken not to deepen the digital divide or introduce bias against minority or vulnerable groups. AI should aim to include students with learning difficulties or disabilities and those studying in languages other than their mother tongue. The consensus recommends a concerted effort to reduce the gender gap in digital skills, promote the development of AI tools to empower girls and women through AI skills and ensure that AI applications in education are free from gender bias.

The consensus also calls for the ethical, transparent and auditable use of education data and algorithms, given that AI can introduce various types of bias and that access to data must be balanced with privacy and protection. The consensus concludes that data should be available for the public good, but that AI development principles and legal frameworks should take account of issues relating to ethics, privacy and security.

Issues relating to ethics and inclusion in AI concern not only AI development and AI practitioners, but also the use of AI. Key questions must be answered, including: What social and personal values should be instilled in AI, given its broad range of applications across different contexts? What ethical boundaries should be set, not only for the technology sector and AI professions, but also for other sectors that use AI? What social expectations will help ensure that AI and its applications are fair, inclusive, ethical and values-driven?

The scope of this paper does not allow for an exhaustive review of all of the ethical frameworks and guidelines that have been developed or are being developed; in fact, such a review has recently been conducted (see Jobin, Ienca & Vayena, 2019). Instead, this section explores key concepts in AI ethics, with a particular focus on some of the challenges that should be addressed by education and training institutions when drafting their own policies and curricula.

Frameworks and principles for ethical AI

Frameworks and principles for ethical AI are currently being developed by a wide range of stakeholders, including intergovernmental organizations, governments, research institutions, private companies, non-profit organizations and professional bodies, all with differing approaches and sometimes even differing definitions for concepts (Jobin, Ienca & Vayena, 2019). It is also important to recognize that the development of AI ethics builds on an extensive body of work, including overarching ethical frameworks such as the human rights framework set out in the *Universal Declaration of Human Rights* (United Nations, 1948) and previous work on the application of human rights in the context of ICT such as the *Code of Ethics for the Information Society* (UNESCO, 2011).

BOX 4 **Common Values and Principles for Ethical AI**

Responsibility refers to the need for someone with authority to change an algorithm and redress the situation in a timely manner in the event of adverse effects. This is sometimes expressed as **human oversight**. This can also refer to the attribution of legal liability, though the literature is divided on which actors are responsible for AI outputs and decisions.

Explainability expresses the need for people affected by an algorithm to understand the outputs or decisions produced by that algorithm. It is sometimes referred to as **accountability**.

Accuracy refers to the fact that algorithms are fallible. Errors in outputs can result from improper or biased inputs or from statistical error. The principle of accuracy requires that potential and actual sources of inaccuracy or uncertainty be identified, recorded and used for mitigation procedures.

Auditability is the ability of third parties such as auditors and the public to access and review, monitor or criticize an algorithm. This principle fosters public trust and can reveal flaws in the algorithm. **Transparency** is used varyingly to encompass aspects of both **explainability** and **auditability**.

Fairness refers to the tendency of algorithms to echo or even amplify human biases, especially those based on historical or social data. The fairness principle requires that algorithms and their outputs or decisions be evaluated for potential discrimination. **Fairness**, or **justice**, can also be used to refer to equal access to AI and its benefits.

Safety and **security** refer to the need to ensure that AI never causes foreseeable or unintentional harm. Harm includes discrimination, violation of privacy and bodily harm, and can also encompass negative psychological, social, economic and emotional effects. **Privacy** is a value that must be upheld and a right that must be protected; it is often presented in relation to data protection and data security.

Well-being relates to the need to promote AI for the good of the public, society, individuals and the economy.

Source: Adapted from Diakopoulos & Friedler (2016) and Jobin, Ienca & Vayena (2019)

The ethical principles for AI developed thus far focus on both humanistic values and data-specific concerns, to varying degrees. At the more data-centric end of the spectrum, the European Commission's Ethics Guidelines for Trustworthy Artificial Intelligence outlines requirements for 'trustworthy AI aligned to European values'. The document cites human agency and oversight; technical robustness and safety; privacy and data governance; transparency; diversity, non-discrimination and fairness; societal and environmental well-being; and accountability (AI HLEG, 2019). To help governments and institutions determine whether these values are adequately incorporated into the construction and use of AI, the European Commission went on to publish the *Assessment List on Trustworthy Artificial Intelligence*[6], which advocates actions such as impact and risk assessments; AI monitoring, oversight and verification systems; system development and process documentation; and data quality, representation and access control procedures. It also highlights key considerations such as whether human users are informed that they are interacting with AI and told the purpose of the AI, the system's resilience to cyberattacks and other vulnerabilities, third-party harm and inclusion.

Interestingly, this example centres on the use of data rather than reflecting on human agency or the context in which AI is used (for example, healthcare or education), a position that has been described as necessary but not sufficient (Holmes, Bialik & Fadel, 2019; Holmes et al., 2021). In an example from industry that centres more closely on human agency, the *IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems* (A/IS) (2019) introduces the following principles for the ethical use of A/IS:

1. Human rights: A/IS shall be created and operated to respect, promote and protect internationally recognized human rights.
2. Well-being: A/IS creators shall adopt increased human well-being as a primary success criterion for development.
3. Data agency: A/IS creators shall empower individuals with the ability to access and securely share their data, to maintain people's capacity to have control over their identity.
4. Effectiveness: A/IS creators and operators shall provide evidence of the effectiveness and fitness for purpose of A/IS.
5. Transparency: The basis of a particular A/IS decision should always be discoverable.
6. Accountability: A/IS shall be created and operated to provide an unambiguous rationale for all decisions made.
7. Awareness of misuse: A/IS creators shall guard against all potential misuses and risks of A/IS in operation.
8. Competence: A/IS creators shall specify and operators shall adhere to the knowledge and skill required for safe and effective operation.

The combined work of UNESCO towards the ethical governance and use of AI provides another example that focuses not only on people but also on sustainable development and associated governance. UNESCO's concept of Internet Universality and its related 'ROAM' principles (an acronym for rights, openness, accessibility to all and multi-stakeholder participation) were endorsed in 2015 (UNESCO, 2015), and the organization has undertaken to explore and conceptualize the ways in

6 https://futurium.ec.europa.eu/en/european-ai-alliance/pages/altai-assessment-list-trustworthy-artificial-intelligence

which AI interacts with these principles and broader ethical considerations. The UNESCO Committee on the Ethics of Scientific Knowledge and Technology (COMEST, 2019) explores the implications of AI, such as the ways in which AI algorithms can affect perceptions of truth or exacerbate socioeconomic and access-related gaps in society and the potential benefits and risks of AI with respect to contexts and factors such as education, cultural diversity, biases and peace-building. The first draft of the *Recommendation on the Ethics of Artificial Intelligence* (UNESCO, 2020) promotes AI development in line with values such as human dignity, human rights and fundamental freedoms, diversity and inclusiveness, environmental flourishing and the promotion of peace. In addition to common principles such as transparency, safety, privacy and non-discrimination, the document presents considerations aimed at promoting multi-stakeholder governance to ensure that AI contributes to development goals and promotes AI awareness and literacy to enable citizens to make informed decisions about their use of AI, and encourages the continuous evaluation of AI to ensure that it is aligned with evolving targets such as the Sustainable Development Goals.

Challenges and considerations for ethical AI

The ethical use of AI involves ensuring diversity in the field of AI, upskilling disadvantaged populations, including ethics in skilling programmes, researching the ethical and social implications of AI and establishing institutional and national rules and policies concerning the fair and transparent use of data. These issues provide ample opportunities for both research and advocacy. At the same time, education and training institutions must also reflect on their own use of AI and their own training programmes to ensure that they are ethical, fair, diverse and driven by investment in sustainable development.

Equal access

> ***It has cost implications, but we must ensure that our campus provides access to world-class technology. The labs must be upgraded and Wi-Fi hotspots made available … during the COVID pandemic we have provided [students and lecturers] with data so they can continue to work.***
>
> *Interview with a higher education administrator, South Africa*

While a variety of open-source tools for AI development such as TensorFlow are widely accessible, access to AI tools, training and information depends fundamentally on connectivity and internet access, in a world in which 3 billion people still do not have an internet connection. While access to technology is rapidly expanding, the distribution of internet users remains uneven; for example, the percentage of the population of Africa who have regular access to the internet is particularly low. Overall usage in urban areas is twice that of rural areas, and the global gender gap in internet use stands at 17 per cent. Those with the least access to the internet are still women and people in rural areas of developing countries (International Telecommunication Union, 2020).

While internet access and the use of ICTs are not yet a reality in some areas, connectivity is now a basic requirement for education and training institutions and their students, and has a direct effect on the type, scope and quality of the training programmes that can be delivered. A key focal point for education and training institutions must be access to technology and related opportunities. This need was further highlighted by the COVID-19 pandemic in 2020. A survey of 1,349 TVET stakeholders in 126 countries on six continents found that, while a mere 28 per cent of TVET respondents reported that they regularly used distance learning for training purposes before the pandemic, 64 per cent reported that they used only remote learning during the pandemic, with just 15 per cent reporting that they had engaged in any kind of face-to-face training (ILO, UNESCO & World Bank Group, 2020). The COVID-19 pandemic led to an increase in teleworking, remote learning and innovations in the TVET sector such as Italymobility, a remote internship initiative supported by teleworking software and AI microtools[7].

Developing countries face additional macro-level challenges in ensuring access, including competing priorities such as high poverty rates, food insecurity and high unemployment, which often lead to low investment in ICT infrastructure and research and development (Shiohira & Keevy, 2019). This is the first challenge that needs to be overcome in the use of AI for sustainable development and has prompted conversations concerning the digital divide. Given its importance to both modern daily life and economic opportunities, there are increasing calls for internet access to be considered a basic human right.

7 http://italymobility.com/virtual-italymobility/

Equity and inclusive growth

While there is a broad consensus that AI will play a pivotal role in economic development, effectively improve production and boost overall income, it is more difficult to anticipate the outcome of the rising use of AI when growth is perceived as a social and not merely an economic phenomenon. AI can help drive both economic and social progress and help countries achieve national objectives such as inclusive growth and development, but this can only happen if the technology is developed in a human-centred manner or with a focus that goes beyond financial gain (Access Partnership, 2018; UNESCO, 2019b). The conditions under which this is likely require both private and public investment and a concerted effort on the part of governments to guarantee human-centred development. To date, few AI policies or strategies position AI and its associated development as explicitly human-centred or equitable. However, concrete steps have been taken in some countries through the establishment of formal institutions, such as Singapore's Advisory Council on the Ethical Use of Artificial Intelligence and Data[8].

Diversity

Other challenges surface in the creation of AI. A particularly concerning statistic is the percentage of women researchers in AI, with estimates based on publications ranging from 12 per cent to 14 per cent. This forms part of a broader challenge related to women in technology, given that women are estimated to comprise just 24 per cent of the computer science workforce and receive on average only 66 per cent of the typical salaries of their male colleagues. This trend shows no sign of reversing any time soon. For example, the share of women with bachelor's degrees in computer science in the USA fell to less than 20 per cent in 2015, and up to 50 per cent of women who do enter technology-related fields end up leaving, more than double the rate among their male colleagues (National Academies of Sciences, Engineering, and Medicine, 2018; West, Whittaker & Crawford, 2019). The global statistics are no better, with women comprising just 35 per cent of STEM students in higher education, and only 1.4 per cent of female workers have jobs that involve the development or maintenance of ICT systems, compared to 5.5 per cent of male workers. Access to finance is another significant challenge for female entrepreneurs, given that 85 per cent of all US venture capital investment went to all-male founding teams in 2019 (Madgavkar et al., 2019).

Gender is not the only diversity-related challenge in AI research and development. While less research seems to have been conducted on the racial and ethnic demographics of AI, Alake (2020) examined the diversity reports of major technology companies in the USA and determined that the percentage of black workers in technical roles was increasing, but remained below 5 per cent for many companies. The demographic homogeneity of AI practitioners creates an inherent challenge, firstly because the issues chosen for investment and development are naturally influenced by the demographic dynamics of developers, and secondly, because diverse teams would likely provide a more effective lens through which to investigate bias in developed software. Some research shows that diverse teams are more innovative and more effective in tasks as diverse as generating profit and determining criminal guilt (Rock & Grant, 2016).

Bias

The existence of bias in the datasets used to train algorithms have resulted in research that shows that facial recognition AI displays both gender and racial bias, sometimes with significant consequences, such as the mistaken identification of criminals (Alake, 2020; Buolamwini & Gebru, 2018). Predictive policing tools have raised similar concerns about the amplification of biases in datasets used to train algorithms (Lartey, 2016), and the use of algorithms in the UK to predict student achievement during the COVID-19 pandemic in 2020 conclusively demonstrated the risk of using AI in this sort of predictive capacity, when the algorithms penalized students in historically underperforming schools and demographics (Walsh, 2020).

Human bias lies at the centre of these examples, and the simple solution is to choose different variables. However, biases are related to long-standing gender and racial equality issues in many fields, which can manifest in unexpected ways. To provide just a few prominent examples, Amazon used an AI human resources tool that was discontinued in 2017 after researchers realized it had taught itself gender bias based on previous résumés and hiring practices (Dastin, 2018), and a Goldman Sachs product, the Apple Card, was placed under investigation in 2019 for allegedly offering women lower limits. The company noted that gender was not one of the variables used by the algorithm (BBC, 2019), a defence that fails to recognize the myriad disadvantageous variables that may correlate with gender. In her seminal book on the topic, *Weapons of Math Destruction*, Cathy O'Neil (2016) outlines a number of ways in which proxies such as home address and shopping preferences have created biased systems that are deployed in a variety of sectors, including healthcare, law and education.

8 https://www.imda.gov.sg/news-and-events/Media-Room/Media-Releases/2019/inaugural-meeting-of-the-advisory-council-on-the-ethical-use-of-artificial-intelligence-and-data

Bias-related issues can be compounded by the fact that deep learning systems still have a 'black box' factor, in which the decision-making process is not made explicit. For example, AI has been shown to predict a person's risk of dying within a year based on electrocardiogram scans, but doctors are unable to identify the factors used by the AI system to calculate patient outcomes (Lu, 2019). Transparency and explainability are important in any context, but absolutely paramount where issues of bias may occur.

Safety and security

Further ethical concerns deal with the ability of artificially intelligent systems to operate without posing a risk or causing harm to humans. While the premise might seem simple, this is actually a complex issue that spans multiple areas, including not only physical safety, but also personal liability, intellectual and legal property rights, and privacy. In 2018, a legal liability imbroglio ensued when a Tesla car operating on autopilot mode sped up and crashed into a damaged road barrier, killing the driver. In this case, liability potentially lay with the technology, the developers, the human driver and the government agencies responsible for road repair, all of which could be seen as contributing factors (Levin, 2018).

AI advances are even being used to underpin some cybersecurity systems, thereby posing new benefits as well as risks. For example, while AI can use a broad range of data to accurately and swiftly identify potential threats, it is fallible. Supervised learning systems can be defeated by something as simple as relabelling code. Cybersecurity failures can lead to individual harm such as information theft and unwanted publicity (Hosie, 2017), ransomware can be used to force individuals or governments to pay to restore access to blocked data (O'Flaherty, 2018), and failed cybersecurity measures could even result in economic instability (Pisani, 2018).

Data ownership and individual agency

Data agency represents another major challenge. The information shared by an individual on any popular platform, such as Facebook, Tiktok or Google, becomes the property of and is centrally managed by the platform, which uses it in various ways, including the creation or refinement of algorithms and the sale or resale to advertising agencies or other third parties, often even without the users' direct knowledge or explicit consent. Moreover, if one of these platforms were to delete an account, the user would lose all data linked to that account.

This is also true of education data. Credentials and other information related to student life, purchases, activities and so on often rest with the institution. To access a copy of a degree or transcript, students must request the information from the university and are often required to pay a fee. However, there is a movement calling for individuals to have greater ownership and control over their own data through self-sovereign identity (SSI).

In short, SSI is the basic concept that control over identity data should be transferred from centralized authorities to individuals. This requires a paradigm shift from the sort of relationship in which institutions or companies assign users unique identities and then centrally control related data to a new model in which individuals have online identities that they themselves control in peer-to-peer data exchanges. Data authentication is cryptographically secured, most typically on distributed ledgers, and the credentials are therefore verifiable and digitally accessible, regardless of the state or functionality of the issuing organization at the time of verification. Thus, self-sovereign identity provides individuals with access to their own data at any time and the capacity to control who can access their records and when.

While the concept of SSI has existed for decades, it could finally be a reality thanks to technologies such as blockchain. For-profit corporations are among the first to generate concrete possibilities in this area. Whether it is possible for a for-profit model to generate equitable and inclusive access, particularly for vulnerable groups such as migrants who may benefit most from them, remains to be seen.

BOX 5 **Example – StudentPass**

StudentPass[9] offers digital identification based on the principle of self-sovereign identity. In practical terms, this is the digital equivalent of a student ID card, passport or other identification document, except that it is created and owned by the student rather than the institution or country. Digital credentials are assigned by institutions and validated by means of digital watermarks, thereby ensuring that credentials and other information shared are trusted and valid. This method of credential assignment and storage benefits individuals in that it allows information to be transferred seamlessly between institutions, such as educational institutions and platforms, and workplaces, and enables them to share their own data at any time through their own established networks.

9 https://credentialmaster.com/student-pass/

Values and skills for the AI era

Education outcomes are not like they were twenty years ago. Now we encourage our students to adapt and embrace change and technology. Things will continue to evolve and professions will become obsolete. We are continuously involved in curriculum renewal.

Interview with a higher education administrator, South Africa

Values and skills are both crucial for effectively integrating AI into all sectors, but particularly in education. The consensus recognizes the need to develop **values and skills** that will enable people to participate in life and work in the era of AI. This requires the development and use of tools to quickly identify shifts in the skills required by the labour market and update curricula accordingly, and also reveals the need for AI literacy skills across all levels of society.

The Beijing Consensus promotes a 'humanistic approach to the use of AI with a view towards protecting human rights and preparing all people with the appropriate values and skills needed for effective human-machine collaboration in life, learning and work, and for sustainable development … AI in the service of people' (UNESCO, 2019c: 4). It is clear from this quote how values and skills are viewed as interrelated and that the work needed to effectively integrate AI into educational administration, curricula and teaching and learning presents opportunities to influence the values and skills inherent in both AI and the education system into which it will be incorporated, in addition to the values and skills the education system seeks to instil in students.

While the two concepts are interrelated, this section is divided into two parts, with a discussion on values followed by a discussion on skills.

Values-driven AI

The promotion of values for the AI era is linked to two interrelated conversations: first, how 'human-centred' AI can be developed for the benefit of society and, second, what new values are required for individuals and industry to successfully engage in AI. The first conversation is heavily intertwined with discussions on ethical AI. This relationship is made explicit in the first draft of the *Recommendation on the Ethics of Artificial Intelligence* (UNESCO, 2020), which notes that values inspire desirable behaviour as the foundations of principles, while ethical principles enable values to be applied to policies and other actions. Given the close relationship with the values presented in the section on frameworks and principles for ethical AI, this section now turns its attention to the second question: what values are needed for individuals to successfully engage in the world of AI?

One advantage of AI is its accessibility across contexts. However, while there are declared universal values such as peace, freedom, human dignity and equal rights (UN, 1948), some values may be unique to one context or to a limited set of contexts (Gabriel, 2020). For example, the types of knowledge that might be considered appropriate for public release may differ according to culture. The importance attached to competing priorities may also differ; for example, the extent to which a particular country values employment over corporate efficiency. To further complicate matters, some individual or social values may shift in response to circumstances or the introduction of new knowledge. In fact, it is this capacity to shift that enables values to be introduced through education and training. This can complicate a seemingly straightforward conversation.

Areas of overlapping consensus, or universal values, represent the clear starting point for ethical frameworks for AI and discussions on values in the era of AI, since 'AI can be aligned with human rights doctrine while avoiding the problems of domination and value imposition' (Gabriel, 2020). In its list of 'universal human values', the IEEE includes respect for declared human rights, safeguarding the environment and natural resources, and creating AI 'in the service of all people, rather than benefiting solely small groups, a single nation, or a corporation' (IEEE, 2019).

AI is created by technical experts, who are trained within tertiary education systems. Traditionally, engineers and technicians are trained with an eye for optimization or to create products that perform using the minimum number of resources. It is clear that, considering the significant impact AI can have on societies and individuals, AI practitioners must bring more to their profession than this clinical detachment; they must incorporate ethical reflection into the design process, a concept termed 'ethically aligned design' (COMEST, 2019). The first level of values engagement must therefore be embedded in the training curricula for AI practitioners.

There is also a need to develop an overarching consensus aligned to universal values at the level of AI users, who must develop an awareness of ethical considerations such as inclusiveness, non-discrimination and fairness, social responsibility and environmentalism, and to instil the values that underpin these. In addition to building these values, education and training institutions should align their own programmes and courses to key conceptual understandings of political freedom, democracy, access to and control of personal data, and adherence to national laws.

The conversations in previous sections began to touch on very real challenges to values-driven AI. The primarily profit-driven approach to AI development constitutes a direct challenge to calls to create AI in the service of all people rather than to benefit an organization or corporation. International political tension over control of ICT infrastructure and policy mandates heavily invested in national structures for AI research and development indicate a new level of competition for primarily national benefit. AI development, and the technology sector more broadly, are not inclusive or diverse, and the financial and social benefits of integrating AI into work and society are unequally distributed both within and between nations. While there is a growing movement calling for individual control over data and data privacy, these often clash with the 'big data' needs of the AI industry and its projected importance for wealth creation and economic growth.

However, this is precisely why values in AI is such an important conversation. AI could represent a huge opportunity to move towards sustainable development, advance universal human rights and pursue social equity and economic prosperity for all, but such aspects are not necessarily intrinsic to the technology. To achieve these goals, AI must be aligned with and even embedded within rights-focused social and governance practices and ideals. For example, while there is ample evidence of a gender divide in STEM, there is a need to invest in more research to determine additional factors that may inhibit female participation and, as these factors are revealed, to take legislative action or commit resources to addressing them.

BOX 6 **Example – Employment and Growth, Networked Economies, Foundations for Innovation, Kenya**

The project[10] is underpinned by three pillars: a challenge fund for innovation and applied research hubs; gender mainstreaming in vocational training; and a research fund to support problem-based action research with links to local community development. The project is expected to increase the employability, productivity, competitiveness, efficiency and income of male and female graduates from the TVET skills development system and to enhance the participation of the private sector. The project will be implemented by Colleges and Institutes Canada in partnership with two local institutions, Linking Industry with Academia and the Rift Valley Technical Training Institute.

A final point on values in the era of AI is that distrust of AI remains a significant issue worldwide. Some of this distrust is the result of prominent examples of the misuse of AI, such as those briefly discussed in the section on ethical and inclusive AI. Another consideration is the economic consequences of AI, which include a decline in job security and even displacement for many workers. In his 2019 book *The Technology Trap: Capital, Labor, and Power in the Age of Automation*, Carl Frey argues that the shifts created by industrial revolutions include a high degree of wealth disparity and social change, and draws parallels between current and historical events in this context.

Other contributing factors include a poor understanding of AI and the perceived lack of alignment between AI and social values. In response to the need to upskill populations with a basic understanding of AI, countries such as Finland and the Netherlands have embarked on campaigns to provide training on the basic principles of AI for up to 1 per cent of their population. These initiatives demonstrate that coursework and required learning outcomes should not only encompass the skills and theoretical knowledge related to physical or labour demands, but must also instil an understanding to create informed consumers of AI products who have basic knowledge of AI and are able to identify and respond to issues such as data privacy, equity, bias and sustainability.

10 https://www.idrc.ca/en/project/supporting-innovation-technical-and-vocational-education-sector-towards-productivity-and

BOX 7 Example – Elements of AI, Finland

Elements of AI[11] is a free online course developed by Reaktor, an international strategy, design and technology company, and the University of Helsinki to 'demystify AI', with the aim of 'helping people to be empowered, not threatened, by artificial intelligence'. The course is available in two parts, the first of which requires no maths or programming and provides content 'for everyone interested in learning what AI is, what is possible (and not possible) with AI, and how it affects our lives'. The second part explores actual algorithms and AI methods. To date, over 550,000 students from 170 countries have participated in the programme and, notably, 40 per cent of these were female, double the average for computer science courses.

Following the programme's success in Finland, other countries began launching similar plans. Jim Stolze, who initiated the programme in the Netherlands, describes the course as a response to the need for everyone to engage in AI from an informed position, given its importance in daily life. 'How does it work under the hood? Who is responsible for it? How do you prevent algorithms from contributing to increasing inequality, or creating unity? These are the crucial questions. In the Netherlands, everyone has an opinion, but few people have read into this matter. By offering a basic course to all Dutch people, we can at least enter the discussions in a well-informed way'
(Stolze, quoted in Brouwers, 2018).

Skills for the AI era

Concerns about the impact of AI on the labour market are as widespread as concerns about the gaps between existing and required skills. In this context, there is a great deal of focus on skills development, particularly in high-end jobs such as engineers and researchers. However, AI can be applied to a wide range of sectors and fields, and this scope is set to increase in the future. As we have seen, the integration of AI into social, political and economic life has also resulted in ethical, legal and moral challenges that will impact individuals regardless of their level of education or profession.

In addition, there will be a rise in demand for both core AI professionals and those who are not AI core specialists but who will be required to successfully integrate AI into functions in the sectors concerned. In fact, high-level skills depend on a wide spectrum of AI-related skills at different levels and in different sectors and areas. These related skills will be needed to work in AI-adjacent roles that involve working with AI rather than developing it at the most complex levels. However, strategies aimed at strengthening jobs requiring lower and intermediate skill levels have received little attention.

BOX 8 Example – ProgeTiger Programme, Estonia

The ProgeTiger Programme[12] launched in 2012 aims to introduce programming and robotics into educational curricula across pre-school, primary and vocational levels. This programme is managed by the Information Technology Foundation for Education (Hariduse Infotehnoloogia Sihtasutuse, HITSA), which is, in turn, funded by the Estonian Ministry of Education and Research. The Government of Estonia set HITSA's objective of ensuring that 'sufficient age-appropriate digital competence necessary for further studies and to succeed in society is acquired at all levels of education, by integrating the use of digital solutions into the entire process of teaching and learning" (HITSA, 2015). The ProgeTiger Programme focuses on three areas, two of which are directly related to the development of AI-related skills: engineering sciences, including programming, robotics and electronics; and information and communications technology, including computer science and digital communications.

11 https://www.elementsofai.com

12 https://www.hitsa.ee/it-education/educational-programmes/progetiger

It is also accepted that AI skills should be built on a foundation laid in secondary and even primary school, and this has led to the introduction of computer literacy, coding, programming, robotics and similar subjects into curricula for all ages. These skills are exploited not only in AI talent development programmes but also across sectors and fields that incorporate AI.

AI occupations can be described as a spectrum or a pyramid, with lower-end jobs related to data clearing, data preparation, data curation, data protection and data quality at the bottom; more focused intermediate occupations that use AI, such as data entry keyers and professionals trained to use AI tools in specific domains like maintenance and assistive technology and to apply AI to service sectors, in the middle; and, finally, higher-end occupations such as AI developers, chief data officers and data analytics engineers at the top. The example of a data entry keyer[13], as a typical intermediate level job, is expanded upon in Table 2 to illustrate the tasks and activities associated with this level.

The availability of accredited talent is as limited as initiatives to develop AI talent are numerous. In 2018, Element AI estimated the total global talent pool in AI to be 22,000 PhD holders, with around 90,000 practitioners if lower education levels are taken into account (Kahn, 2018). By either estimate, countries with ambitious targets of becoming AI leaders are vying for a limited pool of global talent in the sphere of AI, and policies therefore reflect efforts to both attract and develop national talent such as visa and entry reforms, financial incentives, incentives or funding for the development of new tertiary courses or training schemes, and curriculum reforms to meet the demand for AI skills.

Governments, industry, the civil service sector and academic institutions across the world are involved in a number of programmes to boost interest and engagement in STEM subjects. Opportunities include events such as Africa Code Week[15], longer initiatives such as community-based or mentorship programmes like those offered by Technovation[16], internships or apprenticeships, and massive open online courses (MOOCs) such as those offered by Lynda[17].

TABLE 2 **Typical activities and tasks for a data entry keyer**[14]

ACTIVITIES	TASKS
Locate and correct data entry errors, or report them to supervisors.	Interacting with Computers — Using computers and computer systems (including hardware and software) to program, write software, set up functions, enter data, or process information.
Compile, sort, and verify the accuracy of data before it is entered.	Processing Information — Compiling, coding, categorizing, calculating, tabulating, auditing, or verifying information or data.
Compare data with source documents, or re-enter data in verification format to detect errors.	Documenting/Recording Information — Entering, transcribing, recording, storing, or maintaining information in written or electronic/ magnetic form.
Store completed documents in appropriate locations.	Communicating with Supervisors, Peers, or Subordinates — Providing information to supervisors, co-workers, and subordinates by telephone, in written form, e-mail, or in person.
Select materials needed to complete work assignments.	Getting Information — Observing, receiving, and otherwise obtaining information from all relevant sources.

13 Linked to this occupation others are mentioned including Data Capture Specialist, Data Entry Clerk, Data Entry Machine Operator, Data Entry Operator, Data Entry Specialist, Data Transcriber, etc.
14 https://www.onetonline.org/link/summary/43-9021.00

15 See https://africacodeweek.org/ for more information.
16 See https://www.technovation.org/ for more information.
17 See https://www.lynda.com/Data-Science-tutorials/Artificial-Intelligence-Foundations-Machine-Learning/601797-2.html for more information.

BOX 9 **Adams State University's summer High School Apprenticeship Research Programme in AI and Robotics, USA**

The Adams State University[18] summer programme is funded by grants from the Army Research Office that allow two high school students to participate with teaching staff and university students in the Undergraduate Research Internship Programme in Artificial Intelligence (AI) and Social Robotics, also funded by the US Army. The programme provides high school juniors and seniors with hands-on experience of developing and presenting scientific research. It also aims to create a pipeline of students interested in undertaking a bachelor's degree in a STEM subject (engineering, computer science, information technology and mathematics). The eight-week apprenticeship is held in June and July.

In addition to the rise in demand for digital skills in most middle-skill and high-skill occupations, an analysis of jobs vacancy data reveals a new range of skills that need to be adopted across several technical disciplines, including data manipulation, statistics and real-time analytics, business analytics and visualization.

The skills needs of the labour force are also changing in less direct ways, with demand for soft skills such as teamwork, collaboration and leadership also on the rise. A recent global survey of employers found that 80 per cent of companies cited a shortage of soft skills (Bersin, 2019). In Myanmar, an analysis of labour market demand between 2017 and 2019 revealed an increase in demand for skills to handle administration and transactions and found that employers specified soft skills such as collaboration in addition to technical skills. In addition, most employers requested prior work experience, which underlines the benefits of work-integrated learning programmes (UNESCO, 2019d).

18 https://www.adams.edu/news/adams-state-offers-summer-high-school-robotics-apprenticeship/

Identifying skills needs

The identification of new qualifications, fields and skills in demand often rests upon industry advisors and periodic surveys from government. Research into current practices revealed the existing integration of industry into some institutional governance structures of education and training institutions, particularly those related to curriculum development and work-integrated learning:

> ***As a department, we are required by the government to have an advisory board as a statutory body for each department as a quality measure. Sixty per cent are industry members or partners who can provide the department with input. This helps us embrace market changes in a number of sectors, and they have further helped us introduce software and ICTs and advised us on their use.***
>
> *Interview with an education and training administrator, South Africa*

While the skills identification process remains cumbersome or fragmented in many contexts, countries such as Australia, Estonia, Myanmar, Singapore, South Africa and Tunisia have investigated the development of tools that leverage AI to connect education, jobseekers and the labour market without the usual delays associated with market research and reporting. For example, Burning Glass[19] determines the set of skills required by the labour force based on the characteristics of job vacancies and can therefore track skills demand and the rapidly evolving skills needs of the workforce in near real time.

Skills matching technology can also help educational institutions build or review responsive course and training options. However, the flow of information between different layers of governance (regional, national, provincial, institutional, etc.) needs to be coordinated such that relevant data can be exploited in a timely fashion. This requires both advocacy and communication between governments and education and training institutions, with information and recommendations flowing in both directions.

19 https://www.burning-glass.com/

BOX 10 **Policy example – The Jobs and Education Data Infrastructure (JEDI) project, Australia**

JED[20] was set up by the Department of Employment, Skills, Small and Family Business and is overseen by the Australian Bureau of Statistics (ABS). The project focuses on the creation of a data engine that brings together employment and education data that can then be fed into other applications, including policy research. The data collected includes information on higher education, technical and vocational training and the labour market. A major component of this project is a Skills Match Tool based on traditional data such as student achievements and labour market information, and also incorporates new methodologies such as internet job vacancy analysis by means of Burning Glass AI technology. The Skills Match Tool uses this information to provide new insights about potential transitions affecting the future and current labour force by highlighting emerging or expanding jobs or industries related to or leveraging existing skills. Jobs can be researched by individuals by means of a set of online consumer tools such as job search platforms, which highlight aspects of potential careers, including the tasks and requirements associated with the job, salary and future prospects. Jobseekers can then access more information on the skills and knowledge required and any relevant further education courses available.

However, even as the focus shifts to new skills, there would be value in considering future possibilities before entirely phasing skills out of national curricula, particularly technical and mechanical skills. For example, investments in infrastructure may lag some way behind the rate of innovation and require skill sets that do not respond solely to the latest innovations but actually encompass retrospective design too.

These days, we are looking mainly at new qualification requirements. But what happens to the skills and qualifications we already have? Are they needed? Can we get rid of them? What about skills not needed in routine situations? If we lose skills and processes and then need them later, what will we do? How can we maintain the skills that are not used very often due to automation?

Interview with a BIBB representative

20 https://www.nationalskillscommission.gov.au/our-work/forecasting-skills-and-analysis

AI to empower teaching and learning

The use of AI in teaching and learning has become a frequent topic of discussion in the current educational climate. Researchers and practitioners have introduced AI into conversations related to many of the most intransient challenges in education, such as teaching quality, differentiated learning, education in emergency situations and migration.

The Beijing Consensus calls for the use of AI to empower teaching and learning. Suggested target areas include AI to support learning and learning assessments (particularly to assess multiple dimensions of students' competencies), AI tools for interdisciplinary skills and competencies, and AI for adaptive learning processes. The consensus focuses on teachers as the users of AI, and AI as a tool to facilitate more inclusive and effective teaching and learning.

In addition to the desktop research and policy reviews conducted for this paper, four education and training institutions and two government agencies involved in supporting TVET institutions were interviewed regarding the ways in which AI and associated technology are being leveraged in teaching and learning. This section provides a brief overview of some of the results of this research.

> ***We now teach students AI as part of their coursework and provide them with basic knowledge to serve them throughout their careers. Researchers at the university from a wide range of disciplines now use AI as part of their analysis or as a predictive model to complement experimental work. With the AI toolkit becoming ever simpler to use, the challenge has shifted from one of computation to one of library preparation and imagination.***
>
> *Interview with an education and training administrator, Japan*

AI in education and training institutions

> ***The volume of data produced by modern research equipment is enormous. AI offers a way to analyse this data at a scale and depth that were previously impossible, thus paving the way for new areas of research and discovery.***
>
> *Interview with an education administrator, Japan*

When properly embedded within appropriate and robust values frameworks and ethical guidelines, AI has the potential to empower teaching and learning at classroom level and through administration, enabled in part by the vast amounts of data that pass through individual institutions and their respective systems and networks. AI has been applied to administration, instruction, identification of at-risk learners, intervention, marking and planning. Open educational resources (OERs) offer a wealth of information, and AI applications such as the Learning Referral Network have been set up to provide personalized curation of digital repositories[21]. Chatbots such as the Digital Intelligence Virtual Assistant (DIVA) have been deployed at tertiary education institutions to respond to student queries and reduce the demands on staff (UNESCO, 2019a). Resources such as LabXchange[22] and Open Source Physics[23] provide learning experiences in computer modelling and virtual simulations, thereby potentially saving teacher time in experiment preparation and providing learners with digital skills.

21 https://www.curiouslearning.org/learn-from-home
22 https://about.labxchange.org/
23 https://www.compadre.org/osp/

BOX 11 **Example – AI for Youth, UNESCO**

In partnership with Ericsson, UNESCO launched AI for Youth[24] to develop AI skills in young people. As part of the project, an online repository of resources to teach young people about AI – how it works, how it might be used and how it may affect humanity – was developed. The repository is designed to support teachers and curriculum designers to upskill their own abilities and integrate AI skills development into school curricula.

The project will also involve the development of an AI skills framework for K-12 schools and support the integration of AI training courses into national curricula in selected countries.

Research participants detailed some of the ways in which AI, and technology more broadly, is used in their institutions:

- In South Africa, the introduction of platforms and learning management systems has helped reduce the administrative workload of academic and support staff. Students are able to sign in from any location, whether on campus or not, and biometric tags provide access to campus resources in some institutions. Platforms, portals and learning management system resources have become core elements of students' everyday interactions and communication between lecturers and other institutional staff, particularly in the context of the Covid-19 pandemic.
- In Malaysia, Universiti Tun Hussein Onn is developing a chatbot that will serve as a learning tool to provide students with guidance and instruction outside of operating hours.
- Predictive algorithms such as those used by Change Dyslexia[25] are being used to screen for learning difficulties based on observed phenomena such as reading speed and eye tracking.
- AI personal assistants such as X.ai and Google Calendar perform administrative tasks such as scheduling, rescheduling and cancelling meetings or lectures.

AI intelligent assistants are in the pipeline to help with a range of administrative needs, including budgeting, student applications and enrolment, course management, HR-related issues for educators, purchasing and procurement activities, expense management and facilities management.

Interview with an academic, Mauritius

- AI is being used in software such as plagiarism detectors and real-time translation services.
- 'Smart classrooms', which enable lecturers to monitor students' behaviour and character, are being explored as a research tool to determine levels of engagement in different activities and media, and will provide information that can be used to tailor instruction to student interests more effectively.

We can use technology to monitor student engagement levels during different activities, such as problem-based learning and videos. We want to observe students and create teaching methods that are more suited to Gen Z.

Interview with a lecturer, Malaysia

- AI can also be used to reduce teachers' administrative workload and to assist with grading and feedback on individual tasks.

24 http://teachingaifork12.org/
25 https://www.changedyslexia.org/

BOX 12 **Example – Letrus, Brazil**

Letrus[26] is an AI-backed platform that seeks to improve students' writing skills in Brazil by mitigating challenges related to effective and timely feedback. The founders of Letrus, an EdTech company, noted that students' essays were sometimes returned by teachers months later, sometimes with only cursory comments. The Letrus AI platform was designed to provide timely, detailed feedback. Essays are submitted on the platform and analysed by an AI system that has been trained using over 5,000 high-quality essays. The system leverages existing tools such as spell checkers and plagiarism detectors, as well as its own algorithm, to provide immediate feedback on the essay's structure and language use, suggestions for improvement and a provisional score based on the content. This is then reviewed by a teacher, and the essay is returned to the student within three days. Teachers access a portal with information on class performance, including common errors, challenges and individual student submissions, and are able to add their own comments or challenge the conclusions of the AI system. Teachers also remain the point of contact for students regarding their work. This approach provides opportunities for targeted class support and ensures that teachers remain the key facilitators of the educational journey, with AI merely as an additional support tool.

The research participants also suggested that AI could be used to steer individuals into promising career paths based on historic graduate outcome data, based on inputs such as socioeconomic background, coursework and current jobs, and to determine suitable task allocations for lecturers based on their past performance. This echoes the prominent uses of AI in human relations and particularly recruitment, where 'the ubiquitous interview is being supplanted (or augmented) by digital interviews that rely on consumer grade equipment to translate candidates vocal and facial behaviours into a psychological profile or an estimate of their potential fit for a role, based on the prediction of their future job performance or employee engagement level' (Akhtar et al. 2019: 178).

26 https://www.letrus.com.br/

BOX 13 **Example – The New Venture Institute at Flinders University, Australia**

The New Venture Institute[27] is the entrepreneurial arm of Flinders University and links business, government and the community to university assets such as students, lecturers and infrastructure with the goal of creating impact through capacity building. The institute focuses on helping individuals, businesses, educators and researchers prepare for a continuously disrupted future environment. The NVI creates a space for new entrepreneurs to connect to leading industry experts and work on the development and marketing of new products, thereby creating opportunities at the intersection of business incubation, education and industry innovation.

This sort of algorithm may improve upon low reliability rates, at least for unstructured and structured interviews. A meta-analysis by Cook (2004, cited in Akhtar, 2019) found that the validity coefficient for unstructured interviews as predictors of job performance was as low as $r = .15$, with structure interviews faring only slightly better at $r = .28$. However, careful consideration should be given to the ethical application of historical data to unique individuals. AI will generate a recommendation based on probability, but in the process it might also assign unnecessary limitations to individuals, who have unique capabilities and characteristics that will undoubtedly influence their outcomes. As noted in previous discussions, human agency should represent a core consideration of any AI development and deployment.

The research also cited curriculum reform, as seen, for example, in the integration of design thinking into TVET coursework in Singapore and the inclusion of innovation projects such as the Capstone Project for final year students undertaking an Internet of Things (IoT) and big data analytics diploma at Polytechnics Mauritius. The final year project at Universiti Tun Hussein Onn also encourages students to work with the IoT and AI, and can be linked to the Malaysia Technology Expo, national and international competitions and innovation fairs held for students and staff, with the ultimate goal of marketing projects.

Another strategy used to guarantee the right mix of instructional skills and opportunities for practical application is based on incubation centres or labs

27 www.nviflinders.com.au

connected to education and training institutions, partnerships that offer a means of creating an academia-to-industry pipeline for the development of both products and talent. Some higher education institutions have invested in the development of on-campus business incubators to harness the university's resources to conceive of and prototype innovations. As they develop their innovations, students build entrepreneurial skills through interactions such as workshops, peer and lecturer support and industry mentorship.

The challenges of implementing AI innovations in education and training

The most pressing challenges relating to the use of AI in education concerns ethics. The use of factors such as socioeconomic background as a determinant has proven problematic, as seen in the prediction of exam scores in England (Walsh, 2020). The use of technology to monitor students, whether in the classroom or elsewhere, may amount to surveillance. Moreover, there are concerns relating to the extent to which AI can truly measure engagement through visual cues. Principles such as accountability, responsibility, explainability and transparency have to be codified by institutions and upheld in any use of AI, and student and staff populations should make informed and free decisions about their potential interactions with AI.

Even when used advantageously, the ability to take advantage of the proliferation of AI and AI-related tools varies between education and training institutions. Research participants noted that, even with policy and curriculum changes, not all institutions were in a position to take advantage of new opportunities or to deliver new curricula or curriculum requirements. For example, integrating simulations into technician degree programmes was cited by one research participant as a challenge for some smaller technical and vocational training institutions.

> ***Even before the rise in value of AI skill sets, computer scientists were already in short supply in the education sector. The tech giants have attracted large numbers of talented technical staff from the education sector, and these are unlikely to return.***
>
> *Interview with an education and training administrator, Japan*

In the interviews, lecturer capacity was consistently cited as one of the most prominent challenges posed by the integration of AI into teaching and learning. Education institutions are vying not just with each other, but also with industry for the currently limited pool of expertise required to develop the talent of new AI researchers and practitioners. This somewhat limits the level of knowledge available within higher education institutions, thereby causing some students to abandon tertiary education in favour of direct mentorship and training in an industry setting. In addition, some companies in the field of AI, such as Google, have moved towards portfolio-based rather than credential-based application requirements, enabled by collaborative platforms such as GitHub that allow individuals to showcase their own development projects.

The end result is that higher education and training institutions often do not have the internal capacity required for AI development and frequently do not have enough talent, even at intermediate level, to use AI properly.

> ***We lack expertise to develop AI or AI-related courses. We need expert support to ensure that lecturers receive training to enhance their AI skills. Many make mistakes or don't really understand it. Their perception of AI mainly revolves around robots and how robots will replace humans.***
>
> *Interview with a lecturer, Universiti Tun Hussein Onn Malaysia*

In vocational education and training, this is further complicated by low entry-level requirements for lecturers in some contexts; according to the interviewees, a certificate awarded following a weekend course is sometimes enough. In addition to the lack of investment in lecturer development, this can hinder the successful and productive adaptation of technology in teaching and learning.

> ***A great deal of thought and planning needs to go into introducing AI, including understanding whether your customers are ready for the change. They must play an active role in the transition.***
>
> *Interview with an NCVER official*

A further challenge identified by participants related to the scale and uptake of AI technologies developed at education and training institutions. Even when AI expertise is available, solutions that are developed to address education-related problems often remain isolated within individual institutions that lack the capacity or drive to market them more broadly.

Building lifelong learning opportunities through AI

The Beijing Consensus states a commitment to using AI to build lifelong learning opportunities for all, across formal, non-formal and informal learning sectors. The document positions AI platforms and learning analytics as 'key technologies' for 'integrated lifelong learning systems to enable personalized learning anytime, anywhere and potentially for anyone' and urges that attention be paid to the needs of older people and those facing barriers to digital life.

This section reflects on the current trends and practices in workforce and individual skilling and emerging patterns in lifelong learning, and the role of governments and education and training institutions in expanding opportunities for skilling programmes.

A case for learning-integrated work

The paradigm shift from a 'corporate ladder' model (in which an individual 'ascends' in a straight line within a particular field) to a 'corporate lattice' model (in which employment pathways require both horizontal and vertical movement) underscores the need for lifelong learning and skills development to ensure individuals' continued relevance in the workplace (Benko & Anderson, 2010). This shift is explicitly acknowledged in current academic conversations concerning skills and training, but there is also an awareness among the current workforce. For example, 54 per cent of American workers who responded to a Pew Research Centre survey in 2016 indicated that they thought they would need further upskilling during their careers, and 39 per cent of large-company executives surveyed by Deloitte expressed difficulty in finding the talent their companies required (Donovan & Benko, 2016; Pew Research Centre, 2016). Many of the skills shortages lie in STEM fields: science, technology, engineering and mathematics (Rakyan, 2017).

Considering the digital transformation in emerging labour markets is not sufficient; the existing workforce must also be continuously upskilled or rapidly and repeatedly replaced. This recognition of the need for continuous skilling to cope with technological change is already giving rise to innovative continuous and lifelong learning models and is perhaps most directly embodied in the calls for a 'human-centred approach to the future of work' and 'effective lifelong learning and quality education for all' expressed in the *ILO Centenary Declaration for the Future of Work* (2019). One might even consider that the future consists of new models that incorporate not only work-integrated learning, but also learning-integrated work.

Educational institutions are racing to catch up with the need to develop more talent to keep the engine of AI development running. However, not only is education being transformed with respect to science, technology, engineering and mathematics (STEM) curricula, but the education industry as a whole is being transformed by AI.

Interview with an academic, Polytechnic Mauritius

The increasing focus on lifelong learning models, particularly those with ongoing formal or semi-formal credentialling, is giving rise to opportunities for education and training institutions to create and deliver study programmes across borders and to target new audiences. In one scenario that can be envisaged, although the competition for physical study locations in higher education previously resulted in cohorts that were limited largely to continuing-generation students, increasing methods and locations of access and reducing delivery costs could lead to more expansive and inclusive participation in post-school education at a lower cost.

However, there are both pedagogical and cost implications associated particularly with the initial development of innovative delivery models and their associated platforms. In some cases, seed funding for the development of new platforms and/or staff development related to blended or distance learning may be provided through government grants, and partnerships with tech-based companies can provide an external source of skills to design and maintain platforms and content.

> ***Different content development models are also available. Providers can develop content at their own cost and license it, partner with an existing provider such as Coursera to provide content, or pay others for online content and then supplement or adapt that content to specific needs. The risk profiles and available resources and expertise are critical factors to consider.***
>
> *Interview with an NCVER official, Australia*

The role of industry in lifelong learning

Industry is responding to shifting demand and the need to upskill the existing workforce through partnerships with academic institutions and online training providers. For example, conscious of the role played by AI in improving operations and reducing costs, the oil company Royal Dutch Shell has partnered with Udacity, an online training provider, to train its employees in AI, data science, data engineering and other digital fields as part of its professional development initiative. Employees participate in coursework, sponsored by the company, and complete 'nanodegrees' in four to six months (Caminiti, 2020). Employer investment in workforce training is rising; a study conducted in forty-three developed and developing countries revealed that 54 per cent of the employers surveyed were providing their workforce with additional training, an increase from just 20 per cent in 2014 (ManpowerGroup, 2018). However, this investment is subject to regional and national variations. A 2019 study in Myanmar found that only 6 per cent of companies were investing in their workforce, compared to 33 per cent across East Asia and the Pacific (UNESCO, 2019d).

BOX 14 **Example – AT&T Talent Overhaul, USA**

One example of a learning-integrated work pilot is the 'talent overhaul' undertaken by the US company AT&T. To address the requirements in terms of technology and new skills, AT&T is attempting a massive upskilling programme for existing staff in lieu of retrenching and replacing its workforce. Key features of the upskilling programme include corporate restructuring to broaden job specifications, greater performance expectations and fewer job titles. AT&T further invested US$340 million over three years in employee upskilling. To support staff, the company launched an online self-service platform for workforce development, which includes virtual workshops and career planning tools, and developed joint programmes with universities to fulfil reskilling needs. Investments were also made in employee tuition for formal and online courses, and the company created a badge system to signal workers' digital credentials (Donovan & Benko, 2016).

While some practitioners highlighted universities as the first port of call for companies, examples are emerging in which TVET institutions also play a prominent role in industry-academia collaborations, particularly where progression and articulation pathways between TVET and higher education institutions are clearly established.

The core identity of TVET education has always been characterized by strategic collaborations between institutions, students and enterprises (ILO & UNESCO, 2020). TVET institutions engage with industry through research and development, marketing of ideas or prototypes, and industry incubators. One way to leverage student potential, as the critical resource, is by increasing the emphasis on design thinking and entrepreneurship in TVET institutions, which is reflected in models such as those of Singapore, Malaysia and Spain (Koh et al., 2015; Olanrewaju, Ojo & Peter, 2020; UNESCO-UNEVOC, 2020).

BOX 15 Example – Higher Level Applied Technology apprenticeship project, Australia

This is a new Diploma and Associate Degree in Applied Technologies developed through a collaboration between Siemens Ltd and Swinburne University of Technology[28]. Completion of the Diploma in Applied Technologies is linked to the VET system and results in a qualification that enables the holder to work as an engineering technician, while the Associate Degree in Applied Technologies is linked to higher education and qualifies the holder as an associate engineer. Completion of this two-step pathway also directly articulates to a Bachelor's Degree in Applied Technologies. The degrees are designed to meet industry needs and develop high-level technology skills among the workforce of the future, with a focus on science, technology, engineering and mathematics (STEM) skills; to that end, the pilot included a range of topics such as Industry 4.0 and IoT, disruptive technologies and engineering.

These credentials are heavily practical in nature, with more than half the study hours completed through hands-on training at Siemens and other companies. Supervisors and business managers at companies are supported by university teaching staff through on-site observations of students, and the professional development of lecturers is provided by industry to further support their understanding of industry processes and skills requirements. Twenty students participated in the pilot, which concluded in 2020 (AI Group, 2016).

Flexible learning pathways and credentials

Of course, individuals are also expected to continuously engage in upskilling based on self-determination of their own needs. AI has created new opportunities for the decentralized delivery of education and training, and the educational engagements of the future workforce will not be limited to formal degree programmes, but will continue to incorporate independent study that is sometimes unrelated to their immediate professional development needs.

The proliferation of learning platforms, internet connectivity and devices has led to the growth of new educational opportunities, such as microcredentials that are delivered exclusively online, and a rise in distance-learning programmes. Open and distance learning constitutes one of the fastest growing areas of education and offers new opportunities to reach students and reduce costs. Coursera[29], a platform created in 2012 to deliver short, formal courses from accredited education and training institutions via MOOCs, had a user base of 40 million students in 2019, and a number of competitors were providing similar services. New labour-sourcing models such as crowdsourcing and platform work (sometimes identified as part of the gig economy) are creating opportunities for skilled workers (Manyika et al., 2014), but also for non-traditional education and training institutions or platforms such as Outschool[30], a community marketplace of online classes that allows experts in subjects ranging from decolonization of history to role-playing games to design microcourses for students. Initiatives such as the FutureSkills portal in India and the MySkillsFuture portal[31] in Singapore[32] provide initial competency assessments and map learning opportunities to career goals.

28 https://www.aigroup.com.au/policy-and-research/industrynewsletter/industry-extras/industry-4.0-higher-apprenticeships-project/
29 https://www.coursera.org/
30 https://outschool.com/
31 https://futureskills.nasscom.in/
32 https://www.myskillsfuture.sg/content/portal/en/index.html

BOX 16 **Kiron Open Higher Education, Germany**

Kiron Open Higher Education[33] is the social start-up behind the Kiron Campus, a free online platform for displaced people. Students are guided through curricula and certifications compiled from a curated aggregation of OERs such as MOOCs. Study areas include business and economics, engineering, computer science and social science, and initial test-based research indicates that student learning outcomes from Kiron coursework are comparable to university education standards. In addition to these learning pathways, Kiron provides skills-based courses such as language learning, web design, Python and business skills, and connects students directly with employment opportunities. Kiron also offers automated student assistance for university applications.

Skilling pathways and types of recognition, such as the microcredentials offered by short courses and MOOCs, ensure that knowledge, skills and competencies can be built up and refreshed in response to changing work and societal demands. There is also a growing need for robust methods to assess and recognize prior learning in this rapidly changing landscape, where providers and courses may come and go. As discussed previously, self-sovereign identity allows students to control and access their credentials, even if the organization that originally provided them with the credentials is now defunct. Initiatives such as Credential Engine[34] seek to map the competencies and skills of credentials to increase transparency and allows credentials to be compared across contexts. A recent case study in South Africa determined that flexible learning pathways such as alternative admission, supplemental instruction, distance or blended learning, and part-time or time-flexible learning that were 'in the past viewed as "alternative", are now widely seen as being "mainstream" practices' (Bolton, Matsau & Blom, 2020, 12).

Qualifications frameworks also play a role in enabling lifelong learning and workforce mobility and currently have a significant presence in more than 140 countries; there are at least four regional qualifications frameworks at different stages of development, and progress is being made towards the development of a continental qualifications framework for Africa (CEDEFOP, 2018). Slowly but surely, qualifications frameworks are being shaped by new perspectives on digital credentials (Keevy & Chakroun, 2018), the notion of representation (Bjørnåvold & Coles, 2007) and emerging platforms that allow learning records to be validated more authentically (Shiohira & Dale-Jones, 2019).

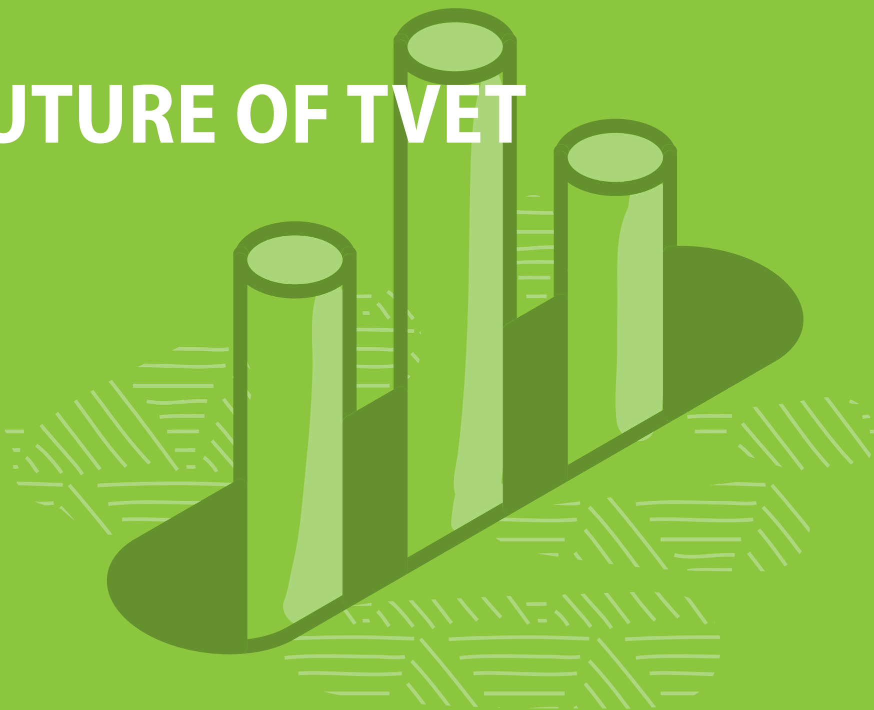
33 https://kiron.ngo/

34 https://credentialengine.org/

3

SECTION 3
AI AND THE FUTURE OF TVET

This paper has explored a number of issues concerning AI in education with respect to intermediate skills, particularly in the area of technical and vocational education, and has drawn on a wide range of research, stakeholder contributions and desktop research. It has laid the foundations for a shared knowledge base among stakeholders on AI-related issues, intermediate skills and shifts in the labour market, and harnessed this to examine the progress made towards human-centred, value-based AI in education and the related challenges. Along the way, the paper has explored a number of policies and educational innovations related to technology and AI. It has demonstrated some of the ways in which AI is adding value to the education and training sector and the ways in which education and training are adding value to the AI sector and other sectors that use AI. The paper will now offer some reflections and address the way forward.



The diversity of TVET contexts

TVET institutions operate within a range of contexts. Some operate in upper-middle-income and higher-income societies where AI is already deeply embedded in legislation and governance, policy, state expenditure, the private sector and the national economy. Many of the TVET institutions in these societies are already playing a leading role in the 'hollowing out' of intermediate-level skills and the integration of flexible learning pathways and AI directly into education and training.

In other countries, governments without the resources or industrial base to develop AI will become clients of governments and private sector companies that own and provide AI goods and services – a second iteration of the 'export raw, import refined' paradigm, whereby developing countries in particular export raw materials such as cotton and import processed or value-added goods such as clothing (Kasahara, 2004). Countries that stick to this routine will likely hire AI consultants and service providers to apply AI to the sectors that need it with a view to ensuring that local production conforms to international value chains. In some contexts, the degree to which AI is currently embedded in governments and businesses is limited, and even more so when it comes to civil society; the impacts of AI remain less comprehensive and far-reaching, and its role as a driver of change in TVET has not yet been established.

Even in these countries, however, it is not a matter of if, but when the change will come about. The transformation timeline may vary considerably between regions and countries but, as the AI industry continues to expand and the uses of AI continue to multiply, countries are likely to increase their engagement. TVET systems that are not proactive in considering the impact of these shifts on their curricula and training programmes run the risk of becoming irrelevant.

Current research indicates that many TVET institutions have yet to form meaningful or robust responses to the changes occurring in the era of AI. It is imperative that TVET institutions, regardless of the context, understand the current and future importance of AI and begin to incorporate AI into their development and planning processes. Forward thinking and, where possible, pre-emptive action will position TVET institutions and their graduates to thrive in the AI era and make a positive contribute to economic, social and individual goals. Failure to do so will have the opposite effect; TVET graduates will be poorly prepared for the labour market and TVET as a whole will lose its status, when precisely the opposite is needed.

Recommendations for international TVET leadership

Ensuring that TVET institutions thrive in the era of AI requires investment from international, national and institutional stakeholders. While this paper has contributed to the ongoing conversation on AI, intermediate skills and TVET institutions, there is a need for further research, ongoing advocacy at different levels of stakeholders and, above all, policy recommendations.

Reach a consensus on AI in TVET

One approach worth considering is a TVET-specific consensus document, created through the same types of engagement and knowledge sharing as used for the *Beijing Consensus on Artificial Intelligence and Education*. Through engagements, conferences, presentations and discussions, it would be possible to build awareness and promote robust conversations among policymakers, researchers and practitioners with a view to influencing policy and practice at various levels.

Invest in specific policy guidelines and protocols

One crucial point of interest is the significant rise in public funding for AI initiatives, including research and development, industrial and investment funds, and related digital infrastructure (Purdy & Daugherty, 2017). However, it is important to note that TVET is underrepresented in government policies, and universities are currently a more prominent target for exploratory research and work.

As an additional step, international TVET leaders could further invest in specific policy briefs, guidelines and/or protocols for governments to involve TVET colleges in their AI plans and strategies, which would take account of ringfenced funding and the participation of TVET college in AI-related industry-academia partnerships as a minimum. The governance recommendations outlined in the next section may also provide some points to consider in such a document.

Invite local stakeholders to participate

Government, academic and non-government agencies engaged in the sector could further be invited to contribute through policy analysis, response papers and advocacy for TVET within specific national contexts.

Recommendations for regional and national governance

The rapid development of AI and related policies demonstrate that governments are aware of the importance of AI in social, political and economic life. The effects of AI are being felt not only in workforce transitions but also in everyday life, where individuals are subject to the influence of 'big data' AI in daily routines, including banking transactions, email and shopping, whether they are aware of it or not.

Undertake policy reviews and updates

The governance priorities in the era of AI are to ensure that citizens are knowledgeable about AI and its role in society, to ensure that individuals are able to make informed decisions about AI, and to create avenues of redress for AI-related harm, should they be necessary. Countries must update relevant policies and laws, including those related to intellectual property, liability, privacy and, of course, curriculum and educational outcomes and policies, to take account of the influence of AI and robotics.

Reform credentialling

In an ideal world, curriculum and associated frameworks such as credentialling would be built or redesigned in such a way as to allow articulated microcredentials to be aggregated into different pathways. This would lay the groundwork for more flexible lifelong learning pathways, in which microcredentials could be added or substituted to incorporate new skills or learning outcomes of existing credentials or, from the perspective of a lifelong learner, to add new qualifications to avoid unnecessary repetition and administration.

Prioritize ICT access

Given its importance in modern life, affordable connectivity for all should be prioritized by governments in both policies and domestic spending. In line with growing calls for internet access to be considered a basic human right, governments and institutions alike must prioritize the infrastructure and human capital required to ensure robust national ICT infrastructure. This includes the prioritization of digital skills in schools.

There is also an implicit awareness that economies, institutions and labour markets may not necessarily benefit equally from AI. Governments must strive to ensure that the benefits are fairly distributed in their own countries, with a particular focus on urban-rural and gender divides.

Ensure that policies for ethical AI are implemented and enforced

Some governments have been very proactive in drafting policies to enable and encourage the integration of AI into their economies, but have been somewhat slower to consider policies governing everyday AI interactions. Many have added ethical guidelines to a 'to-do list' as part of their national strategy. Since this review was conducted, a number of governance institutions have followed up with specific ethics-related policies, and the policy landscape in this regard is changing rapidly. Governments must act quickly to adopt, adapt or develop ethical AI policies and related legal mandates that address issues such as transparency, safety, bias and data ownership.

International bodies can be leveraged to enhance this process. UNESCO, for example, regards the ethics of AI as a key priority and will be working towards finalizing its recommendations for ethical AI in 2021, to complement the draft and definitive ethical frameworks that are already circulating.

Develop balanced AI policies that address both social and economic needs

Human-centred AI, or AI built on ethical design principles and used in line with accepted universal values, requires human-centred AI governance. Governments that have not already done so should take steps to set out or amend strategies that explicitly seek to manage labour market transitions and to distribute the benefits of AI. As noted by Huawei CEO Ren Zhengfei at the 2020 World Economic Forum, the business of technology is wealth creation, while wealth distribution is a social issue (Harari, 2020). Governments must take this responsibility seriously and ensure that balanced policies and strategies are in place that not only encourage growth but also protect personal privacy and the current workforce, support lifelong learning and provide vulnerable groups with opportunities to access and benefit from technology and AI.

Recommendations for TVET institutions

TVET institutions will differ considerably in terms of how they confront, incorporate and respond to AI initiatives. However, it is the position of this paper that all TVET institutions, regardless of the national context, must engage in AI. This is true even for institutions that currently do not have connectivity and is essential regardless of where their country currently stands on the AI adoption curve.

Research the available AI tools

This paper has referenced a number of the AI tools and AI-related training programmes that are available. However, more are being created daily and the field of AI is rapidly evolving, based on a body of knowledge that is growing exponentially. This paper argues that understanding AI and its role in society is a transversal skill that all students should be equipped with. It therefore follows that institutions and lecturers must stay abreast of current developments[35].

For institutions with ICT infrastructure, emerging AI technologies and other ICTs offer opportunities to increase efficiency in both educational administration and teaching and learning. ICT is an area in which no one should rest on their laurels for long, since technology is constantly evolving.

Integrate AI and related principles into core requirements (even on campuses without computers)

This does not necessarily mean that every student needs to learn to code, or even to use a computer. While it is true that individual institutions' response capacity hinges partly on national priorities and the availability of infrastructure, even education and training institutions without immediate access to these resources can engage in advocacy and begin implementing elements of design thinking, problem-solving, critical thinking and values for the AI era to develop the transversal skills and common values that are needed. Students can learn about types of AI and learn to identify encounters with AI in their personal and professional lives during routine activities such as banking, shopping and applying for a job. They can examine case studies of legal or ethical challenges posed by AI, such as those described in this paper. Libraries can be expanded to include resources and research related to AI and its implementation from the perspective of sociology, history, law and so on, in addition to industry-specific AI applications and case studies.

Leverage OERs to educate staff and students on AI

Institutions with ICT access can begin developing an awareness of AI among their staff and students, either through professional development and training courses or by providing access to online training programmes such as that offered by the University of Helsinki and other MOOCs to supplement the coursework offered by institutions. Given the urgency and international attention surrounding AI and the strong movement towards open education and OERs, there is no shortage of training materials on AI and AI-human interactions, even for institutions without the capacity to develop these in-house. These resources could be utilized more widely.

Another role for TVET and higher education systems lies in expanding the scope of open resources, to students who learn primarily in a marginalized language, for example. Partnerships could be formed with the original creators or projects undertaken individually to adapt creative commons material to reach a wider audience.

Guarantee the ethical use of AI and student data at TVET institutions

It falls to both institutions and policymakers to ensure that strong value frameworks and ethical guidelines concerning the use of AI are in place.

Educational institutions must make judicious decisions about how and when to use data. For example, the technology to fully automate the student selection process for higher education currently exists. However, transitioning to technology that may be built on existing biases could further disenfranchise

35 UNESCO runs a website with recent AI-related publications and developments at https://en.unesco.org/artificial-intelligence.

certain demographics and eliminate a degree of the transparency, since the decision-making process in some types of AI is not absolutely clear to human observers, which could also lead to errors. This sort of ethical dilemma requires significant consideration before AI is adopted by educational administration.

AI tools to enhance pedagogy should be reviewed to ensure not only that they are fair, accurate, explainable, safe and secure, but also that they are aligned with best-practice pedagogy (Holmes et al., 2021). This is particularly important in a context in which there is an increasing emphasis on complex interpersonal skill sets such as collaboration, leadership and communication. The role of AI in teaching and learning should be carefully considered, and AI tools with limited added value or that are not aligned with the desired learning processes should be discarded.

Embrace self-sovereign identity

The shift towards self-sovereign identity could lead to changes within the field of higher education; in particular, there could be a fundamental shift in the way credentialling occurs and credentials are accessed. Rather than education and training institutions controlling degree information, for example, students could assume that role and responsibility. Education and training institutions could assign credentials to individuals, who could then transfer them to any context. One advantage of such a paradigm shift would be the increased mobility of credentials, which could be transferred across borders, even during conflicts and other emergency contexts. Self-sovereign identity could also streamline learning records across various platforms, which could open up new opportunities for individuals to construct their own relevant lifelong learning pathways.

Make continuous efforts to integrate AI into educational administration, teaching and learning

Institutions seeking to build technology and AI into their coursework in a decisive manner must pursue strategies such as sourcing and integrating AI tools into administration and classroom practice and engaging in regular curriculum review and design processes, accompanied by the recruitment of new staff and investments in the professional development of lecturers. Participation in AI-focused conferences and innovation competitions, in addition to regular research, can help lecturers and educational administrators keep abreast of developments and opportunities in the sector; this task, along with disseminating the findings and opportunities at different levels of the institution, should be incorporated into the portfolios of new and existing staff.

However, this goes hand in hand with a recommendation to ensure that every innovation is scrutinized to guarantee that AI tools are aligned with the institution's values, ethics, principles and guidelines.

Capitalize on and create diversity initiatives in technology

Education and training institutions should capitalize on government and industry initiatives to improve participation and diversity in the technology sector. Alake (2020) cites a number of industry-driven initiatives to increase the share of minority students in technical fields. Outreach activities to connect such learning opportunities to education and training pathways and the development of tailored support systems for minority and female technology students could improve participation, retention and throughput.

The factors that deter women and girls from engaging in STEM fields are complex and varied. One study found that girls perform better at open-ended questions, and that multiple-choice questions account for up to a quarter of the difference in scores between males and females (Reardon et al., 2018). According to one research participant, changes as simple as reducing the amount of personal information required to register caused the female participation in online courses at their institution to double. While significant research has been carried out on trends, inhibiting factors and recommendations for policy (EQUALS & UNESCO, 2019), more research on the strategies that will increase women's presence in ICT is required, and there should be a dedicated financial and social commitment to enact the practices recommended in this regard.

For example, an area in which education and training institutions often have direct influence is diversification of their own professional staff. Ensuring that technology departments and courses have diverse, gender-balanced staff will create welcoming environments for potential students from all backgrounds. Conversely, falling into a 'culture trap', in which candidates are selected based partially on their 'cultural fit' for a department with a largely homogeneous demographic, will only serve to perpetuate inequalities.

Invest in academia-to-industry pathways

As seen in other sectors, TVET colleges should seek ways to engage innovative and practical learning pathways both in the AI industry itself and in AI-related fields such as robotics, data science and computer science. This paper has provided examples of internships, apprenticeships, business incubators and integrated learning pathways, including TVET, higher education and industry.

Strategies may also include investments in AI industry representation in governance structures such as department and institutional boards and advisory boards, planning and fundraising for innovation centres, advocacy for TVET representation on academia-industry-government partnerships and, in countries that have invested in AI hubs, the creation of satellite campuses near these resources.

Finally, the joint appointment of AI professionals represents one avenue to mitigate against the challenge of attracting top talent to academic institutions, which offer less lucrative and often more poorly resourced contexts than industry. Another common aspect of AI policy initiatives is the strong promotion of AI talent development and attraction, which may include plans such as specialized visas and funding linked to AI training programmes. TVET and higher education institutions should both seek to capitalize on such incentives.

Conclusion

The AI era has already given rise to significant changes in the way people interact with each other and their environment. So far, the rate of innovation has exceeded the rate of policy development, and certainly the rate of curriculum reform, thus creating new challenges, some of which are already in the process of being solved through the use of AI.

AI uses will continue to grow and astonish. However, this paper argues that education and training institutions' engagement with AI must be immediate and multidimensional. As the demands of the labour force continue to shift, education systems must be prepared and equipped to promptly respond to both job-specific skills and the transversal skills required to navigate new ways of working and to the renewed requirement for lifelong learning and continuous upskilling. Trends in automation are expected to displace millions of workers, who will need to reskill. As the ways in which humans and machines intersect and interact continue to grow, education and training institutions must ensure students are able to understand and navigate these interactions, so as not to be excluded, or worse, exploited.

Rising to these challenges will require ongoing investment in infrastructure, the professional development of lecturers and other staff, curriculum reviews and multi-stakeholder institutional and departmental governance. Individual institutions and whole systems may face financial and human capital shortages, or have to navigate competing priorities, or possibly even change established ways of working.

Yet, despite all this, these are exciting times. For those who embrace the technology, AI offers a wide range of previously unavailable tools, new ways of looking at data and the world, new ways of connecting and discovering, and new solutions to old challenges. While the COVID-19 pandemic exposed the digital divide, an encouraging number of TVET institutions showed remarkable adaptability by offering distance learning, thus creating avenues for more flexible learning methodologies in the future. This is particularly meaningful, since TVET institutions often have strategic advantages such as lower costs and industry links that could benefit both active workers and students.

It will take a concerted effort by international bodies, governments, institutions and employers, but with considerable and targeted investments in infrastructure, human capital, ethical design and values-based deployment of AI, the future could be a world in which the recognition of prior learning, continuous lifelong learning opportunities, ICT and industry-academia collaborations give rise to high-quality skilling opportunities and significant progress towards inclusive growth and development.

Appendix: List of reviewed policies

Country	Strategy
Australia	National Innovation Strategy *https://www.industry.gov.au/policies-and-initiatives/boosting-innovation-and-science*
Canada	Pan-Canadian AI Strategy *https://www.cifar.ca/assets/pan-canadian-artificial-intelligence-strategy-overview/*
China	Artificial Intelligence Development Plan *https://flia.org/notice-state-council-issuing-new-generation-artificial-intelligence-develop-ment-plan/* Three Year Action Plan for Promoting the Development of a New Generation Artificial Intelligence Industry (2018–2020) *https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-chinese-gov-ernment-outlines-ai-ambitions-through-2020/*
Denmark	Strategy for Denmark's Digital Growth *https://en.digst.dk/policy-and-strategy/denmark-s-national-strategy-for-artificial-intelligence/*
European Union	Policy and Investment Recommendations for Trustworthy AI *https://ec.europa.eu/digital-single-market/en/news/policy-and-investment-recommenda-tions-trustworthy-artificial-intelligence*
Finland	Age of Artificial Intelligence *https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/160391/TEMrap_47_2017_verkko-julkaisu.pdf?sequence=1&isAllowed=y*
France	AI for Humanity *https://www.aiforhumanity.fr/en/*
Germany	Artificial Intelligence Strategy *https://www.ki-strategie-deutschland.de/home.html?file=files/downloads/Nationale_KI-Strat-egie_engl.pdf*
India	Discussion Paper: National Strategy for Artificial Intelligence #AIforAll *https://smartnet.niua.org/sites/default/files/resources/nationalstrategy-for-ai-discussion-pa-per.pdf*
Italy	White Paper: AI at the Service of Citizens *https://libro-bianco-ia.readthedocs.io/en/latest/*
Japan	AI Technology Strategy *https://ai-japan.s3-ap-northeast-1.amazonaws.com/7116/0377/5269/Artificial_Intelligence_Technology_StrategyMarch2017.pdf*

Kenya	Distributed Legers and Artificial Intelligence Task Force *https://govchain.world/kenya/*
Malaysia	National Big Data Analytics Framework *https://mdec.my/about-malaysia/government-policies/national-bda-framework/*
Mexico	Towards and AI Strategy in Mexico: Harnessing the AI Revolution *https://7da2ca8d-b80d-4593-a0ab-5272e2b9c6c5.filesusr.com/ugd/7be025_e726c-582191c49d2b8b6517a590151f6.pdf*
New Zealand	Artificial Intelligence: Shaping a Future New Zealand *https://www.mbie.govt.nz/dmsdocument/5754-artificial-intelligence-shaping-a-fu-ture-new-zealand-pdf*
Nordic-Baltic Region	AI in the Nordic-Baltic Region *https://www.regeringen.se/49a602/globalassets/regeringen/dokument/naringsdepartemen-tet/20180514_nmr_deklaration-slutlig-webb.pdf*
Poland	Artificial Intelligence Development Policy *https://www.gov.pl/web/digitalization/poland-joins-the-global-partnership-on-artificial-in-telligence* *https://monitorpolski.gov.pl/M2021000002301.pdf*
Republic of Korea	Mid- to Long-Term Master Plan in Preparation for the Intelligent Information Society. Managing the Fourth Industrial Revolution *https://k-erc.eu/wp-content/uploads/2017/12/Master-Plan-for-the-intelligent-information-so-ciety.pdf*
Russia	National Strategy for AI Development *https://cset.georgetown.edu/research/decree-of-the-president-of-the-russian-federa-tion-on-the-development-of-artificial-intelligence-in-the-russian-federation/*
Singapore	AI Singapore *https://www.smartnation.gov.sg/docs/default-source/default-document-library/nation-al-ai-strategy.pdf?sfvrsn=2c3bd8e9_4*
Sweden	National Approach for Artificial Intelligence *https://www.government.se/4a7451/contentassets/fe2ba005fb49433587574c513a837fac/na-tional-approach-to-artificial-intelligence.pdf*
Tunisia	Task Force for a National AI Strategy for Tunisia *http://www.anpr.tn/national-ai-strategy-unlocking-tunisias-capabilities-potential*
United Arab Emirates	UAE Strategy for Artificial Intelligence 2031 *https://ai.gov.ae/wp-content/uploads/2021/07/UAE-National-Strategy-for-Artificial-Intelli-gence-2031.pdf*
United Kingdom	AI Sector Deal *https://www.gov.uk/government/publications/artificial-intelligence-sector-deal/ai-sector-deal* AI Roadmap *https://www.gov.uk/government/publications/ai-roadmap*
United States of America	The National AI Research and Development Strategic Plan *https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/national_ai_rd_strategic_plan.pdf* The American AI Initiative *https://trumpwhitehouse.archives.gov/ai/*

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Education and Training

Artificial intelligence has produced new teaching and learning solutions that are now undergoing testing in different contexts. In addition to its impact on the education sector, AI is substantially altering labour markets, industrial services, agriculture processes, value chains and the organization of workplaces in particular.

Technical and vocational education and training (TVET) contributes to sustainable development by fostering employment, decent work and lifelong learning. However, the effectiveness of a TVET system depends on its links and relevance to the labour market. As one of the major drivers of change, there is a need to better understand the impact of AI on labour markets, and consequently on TVET systems.

In certain middle- and higher-income societies, artificial intelligence is already deeply immersed in legislation and governance, policy, state expenditure, the private sector and national economies. In these cases, TVET institutions are presiding over the 'hollowing out' of intermediate level skills and the direct integration of AI into education and training. Contrastingly, many TVET institutions have yet to form meaningful or robust responses to technological shifts.

Regardless of context, all TVET institutions should develop an understanding of the current and future importance of AI and begin to incorporate its use into their planning. Forward thinking and, where possible, pre-emptive action, will put TVET institutions and their graduates in a position to thrive in the era of AI and contribute positively to economic, social, and individual development.

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4 QUALITY EDUCATION

Sustainable Development Goals