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On

Building digital competencies to benefit from existing and emerging technologies with special focus on gender and youth dimensions

Advance Unedited Draft

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Executive Summary

The world is now undergoing a new wave of industrial revolution driven by the development and diffusion of digital technology. Technologies such as Artificial Intelligence (AI), Robotics, Internet of Things (IoT) are revolutionising the various industry sectors, while mobile phones and the internet are continually being used, adopted, and incorporated into people's everyday lives. Digitalisation has a profound impact on the labour market. In both developed and developing countries, where emerging technologies are fuelling the booms of the so-called new economy, citizens need to be equipped with ICT literacy and complementary skillsets and capabilities if they want to leverage existing and emerging technologies for development.

The paper highlights the opportunities and challenges of existing and emerging technologies on digital skills and competencies, with a special focus on youth and women in developing countries. It explores what skills and competencies are needed to exploit emerging digital technologies, how digitalisation can enhance the strengthening of skills, and what policies are necessary in developing countries to prepare them for the current technological wave. The paper concludes by proposing policy and strategy recommendations to enhance skills and digital competencies for the consideration of countries.

The paper is structured in four chapters:

Chapter 1 briefly reviews opportunities and challenges brought by existing and emerging technologies such as Artificial Intelligence, Internet of Things, and Big Data, particularly in the context of the 2030 Agenda for Sustainable Development. The chapter also examines the potential implications for the labour market from these digital technologies in developing countries. The chapter concludes with a discussion of the importance of digital competencies for the youth and women.

Chapter 2 discusses the implications of digital technologies on the development of digital skills and competencies. The chapter also identifies the types of skills that countries need to focus on to prepare the future workforces for the changing world and to maximise the development opportunities offered by existing and emerging technologies.

Chapter 3 examines the potential of existing and emerging digital technologies in building and enhancing digital skills, particularly in developing countries. The chapter also discusses the potential of technologies for education, for example, MOOCs, remote learning, and virtual reality learning.

Chapter 4 discusses policy considerations that can help countries to develop digital competencies. These include direct policy measures such as education and training, and complementary strategies such as investment, institutional development, entrepreneurship, and the promotion of regional and international collaboration. The main policy considerations are as follows:

1. Identify key skills needed to build up digital competencies through, among others, international collaboration, and incorporate them as a part of the *compulsory* formal curriculum in primary or secondary education, which can be decided and implemented by government of individual member states according to the situation of each country. This also means a change of education regulation that makes basic ICT skills compulsory.

2. Support firms, community school and civil society organisations to provide training of broad skills to existing workforce and the population. This should include broad skills for digital competencies including basic ICT skills for the workplace and in the wider social life, life-long learning capabilities and entrepreneurship skills.

3. Special policies and partnerships to support youth and women in this transition in both the private and public sectors. These include 1) targeted programs for women and youth in terms of financial support, training program, online platform, community activities, and tax incentives to companies who prioritize youth and women employment and digital skill training; and youth and women digital entrepreneurship promotion; 2) incorporating ICT and entrepreneurship skills in high school and vocational education curriculum; 3) policies that support community and non-governmental organisations (NGOs) programs that aim to bridge the digital divide in the society, and with special focus on youth and women.

4. Investment in data resource capabilities, including facilities for data collection, storage, and transmission, and capabilities for big data analysis and capabilities integrating results for policy making and business decision making. This include building national big data centres, rolling out full broadband coverage in developing countries, and regional high-speed computing and processing facilities for big data analysis.

5. Special policy and financial support to encourage entrepreneurship in digital economy sectors such as e-business, automation or digitisation of existing business, or commercial activities that contribute to building digital competencies.

6. Better use of digital methods such as online platforms for international knowledge sharing and capabilities building.

7. Build up public-private-partnership (PPP) in support of training provision, infrastructure development, and data facility building.

8. Reform tax, finance, industry and labour market policies to develop an incentive structure that encourages and facilitates investment and labour participation in the digital economy, for example, tax breaks, low interest rate bank loans, digital SME support funds, and preferential human resource or migration policies for digital talents.

9. Set up institutions such as incubators to support digital start-up companies.

10. Strengthen international cooperation to improve the infrastructure, accelerate the development of digital skills, building data collection, storage and analysis capabilities. International cooperation can also play an important role in developing regulations and ethics in data collection, usage and open access, and in providing a forum for the exchange of good practices and lessons learned.

Introduction

During its 20th session held in May 2017, the Commission on Science and Technology for Development (CSTD) selected "Building digital competencies to benefit from existing and emerging technologies, with special focus on gender and youth dimensions" as one of its priority themes for the 2017-2018 inter-sessional period. This Issues Paper has been prepared to assist the Commission in its deliberations. The paper responds to the call made by the ECOSOC to the Commission to raise awareness among policymakers about the process of innovation and to identify particular opportunities for developing countries to benefit from such innovation, with special attention being placed on new trends in innovation that can offer novel possibilities for developing countries[2].

Digitalisation has created new opportunities and challenges for workers in developing and development countries. To maximize the benefits of new technologies, building digital competencies will be key for individual, organizational and national development. But digital competencies can only be systematically developed through education, including formal and informal, which needs to have a particular focus on gender and youth dimensions. Therefore, education policy needs to accommodate new requirements as part of the evolution for the twenty first century. Despite their critical role in the development of digital competencies, however, education and training policies also need to be accompanied by actions aimed at providing an enabling environment for countries to leverage technologies for development.

The paper highlights the opportunities and challenges of existing and emerging technologies on digital skills and competencies, with a special focus on youth and women in developing countries. It explores what skills and competencies are needed to exploit emerging digital technologies, how digitalisation can enhance the strengthening of skills, and what policies are necessary in developing countries to prepare them for the current technological wave. The paper concludes by proposing policy and strategy recommendations to enhance skills and digital competencies for the consideration of countries.

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[2] E /RES/ 2017/22

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Chapter 1. Opportunities and challenges of new technologies for sustainable development: Impact on jobs and demand for skills

The world is now in the process of a new wave of industrial revolution driven by the development and diffusion of digital technology. Technologies such as Artificial Intelligence (AI), Robotics, Internet of Things (IoT) are revolutionising the various industry sectors, while mobile phones and the internet are continually being used, adopted, and incorporated into people's everyday lives. Digitalisation has a profound impact on the labour market. In developed and developing countries, where emerging technologies are fuelling the booms of the so-called new economy, citizens need to be equipped with ICT literacy and complementary skillsets and capabilities if they want to leverage existing and emerging technologies for development.

1.1 The 4th Industrial Revolution: Opportunities and challenges

Modern technologies have fuelled economic growth and changed the way we communicate, transport, live and work. With the coming of the 4th industrial revolution, new technologies such as the Internet of Things, Artificial Intelligence, autonomous vehicles and 3D printing are becoming embedded into everyday life and adopted in the industrial sector. The emerging technologies in the 4th industrial revolution have rapidly transformed the way individuals live and work, and will revolutionise industrial sectors and services, including but not limited to manufacturing, agriculture, and finance. Technology innovations are developing at an unprecedented speed, as Klaus Schwab, founder and executive chairman of the World Economic Forum describes, "when compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace" (Schwab, 2017). According to the UNCTAD Information Economy Report, digitalisation is also leading to changes in the job market and future employment: while new jobs are created and ways of working are transformed, basic and advanced digital skills are also required (UNCTAD, 2017).

Technological advancement has been accelerating in recent years. Existing technologies such as mobile phones and the internet continue to advance. As mobile networks are upgrading to third generation (3G) and fourth-generation (4G), and mobile devices are becoming more affordable, mobile phones have now become a platform for everyday information seeking and sharing, economic activities, and entertainment. It is, therefore, necessary for policymakers around the world to shift from treating ICTs as merely communicational tools to seeing them as multi-functional devices that can contribute to individual and societal development. Box 1 highlights some examples of future technology trends and their potential.

Box 1: Examples of future technology trends and their potential

Companies are using **robots** not only in manufacturing, but also in industries such as government services, translating, and accounting, which are traditionally dominated by human labour.

Artificial Intelligence (AI) enables computers and robots to accomplish physical, computing, reasoning tasks on behalf of humans, and thus increasing productivity. AI also has applications in other sectors such as health. For instance, it could help to monitor patients' health conditions or even detect diseases. Self-driving cars and drones are replacing drivers and pilots to operate in extreme weathers and accomplish challenging tasks.

The **Internet of Things (IoT)** connects electronics, sensors and devices, helping to build smart homes and smart cities.

Big Data Analytics enables the process, management, and interpretation of large volumes of data generated from various sources, which allows the discovery of human behaviour patterns (i.e. shopping preferences) and improves system performance.

Neurotechnologies bridge human brains and computers and aim to enhance human cognitive abilities.

Nano/microsatellites provide affordable satellite systems for scientific research, military and civilian use.

Blockchain technologies will transform the financial industry by providing a transparent, open and trusted computer networks for value exchange.

In industrial sectors, **additive manufacturing** such as 3D printing technology is applied to produce precise models, spare parts and instruments.

Nanomaterials such as graphene, have implications for energy storage, healthcare, and development of smart functional textiles.

Advances in **energy storage technologies** decrease capital costs of energy systems and enable the decentralisation of energy storage.

Synthetic biology reveals significant findings of genes and enables scientists to manipulate DNA.

Source: (OECD, 2016) .

However, the pace of technological innovations in developing countries is not nearly in parallel with that in developed countries. This is due to the existing gaps in knowledge, infrastructure, and education between developing and developed countries, and also the differences in R&D investment and innovation rates between these countries. As a result, developed countries often transcend developing countries in designing, adopting, and applying new technologies. There is still a wide gap between developed and developing countries in Internet access. In fact, 81 out of 100 individuals in developed countries use the Internet while only 41.3 in developing countries.[3] Nevertheless, the adoption gap is likely to narrow as developing countries are catching up with their developed counterparts in purchasing and applying new technologies. A

[3] ITU Facts and Figures 2017. Available at http://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

policy brief by UNCTAD shows that China has been the biggest consumer of industrial robots since 2013, which indicates new opportunities for international development offered by emerging technologies (UNCTAD, 2016).

Traditionally, there are two differentiated ways of conceptualising ICTs for development (ICT4D): the first one focuses on the top-down and modernisation model that emphasises the governments' or institutions' agenda of ICT4D, for instance, manufacture of ICT infrastructure; the second one centres around users and is a bottom-up model, which aims at inclusive participation for all social groups in using ICTs, for example, the improvement of ICT related services (Unwin, 2009). The second perspective, with users in low-income countries playing important roles in technology development, necessitates substantial attention on the needs, practices, and experiences of users of digital technologies. To fully understand the potential of emerging technologies on the world economy, researchers, practitioners, and policymakers need to take the second perspective when analysing the impact of technologies. As Sein & Harindranath suggest, conceptualising the use of ICT in the development context is equally as important as examining ICT itself, because ICT could become a "knowledge enabler" for national development (Sein & Harindranath, 2004). When technologies become embedded into people's daily lives and adopted by almost every industry, evaluations of social, economic and cultural influences of technologies should also take a paradigm shift: from mainly focusing on the access to examining the use, adoption and domestication of technologies by individuals, organisations and industries.

Digital skills and competencies play key roles in maximising the benefit of technologies in individual, organisational, and national development.

Generally, digital competence encompasses the knowledge and skills required for an individual to be able to use ICT to reach personal goals in their personal or professional life. Consequently, the possession of digital competencies enhances both one's quality of life and the effectiveness of one's work. There is a plethora of scholarly conceptions of what digital competence exactly is[4]. Digital competence should be perceived as not only concerned with technical skills, but more focused on cognitive and socio-emotional aspects of working and living in a digital environment.[5] Therefore the notion is a complex one and includes, apart from digital literacy, skills and abilities such as situational awareness in the digital environment, cultural competence, the capacity to retrieve, synthesize, and disseminate knowledge in different contexts, the skills to actively participate in the online community, the capacity to

[4] See for instance Lankshear and Knobel (2008), Aviram and Eshet-Alkalai (2006) and Eshet-Alkalai (2004). Contribution from Government of Bulgaria.
[5] Eshet-Alkalai (2004)

evaluate the reliability, credibility and legality of online content (critical media literacy), among others.[6]

Empirical studies on the use of emerging technologies show that digital skills and competencies play key roles in maximising the benefit of technologies in individual, organisational, and national development. Increasing use of information searches on mobile phones benefits individuals in Sub-Saharan Africa by providing real-time price information and thus reducing the opportunity cost of accessing market information systems (MIS) (Aker & Mbiti, 2010). Firms could also contribute to improved market efficiency by synthesising online market information in economic activities. Evidence also suggests that the lack of literacy, digital competencies, or familiarity with technologies, on the other hand, will hinder individual and economic development. Since mobile phones have become the sole internet access in many developing countries, an increasing percentage of new internet users only have access to mobile internet. However, scholars point out that mobile Internet is disadvantageous, compared to broadband for users in developing countries because it is subject to 'metered mindsets' (people carefully watch their remaining data credits and curb their use), limited production scenarios (people consume information rather than producing content), and circumscribed functionalities (many internet functions available on personal computers are not available to mobile users) (Donner, 2015). Consequently, to overcome these limitations, it is necessary not only to invest on ICT infrastructure but also to improve and enhance digital competencies.

1.2 Emerging technologies and the 2030 agenda for sustainable development

In September 2015, countries adopted an agenda for sustainable development that aims to end poverty, protect the planet, and ensure prosperity for all. While policies and resources have been established to facilitate the achievement of the 2030 agenda, emerging technologies can also play important roles in realising sustainable development. Box 2 describes selected examples of how technologies can help to achieve the SDGs.

Box 2: Selected examples of potential of emerging technologies to achieve the SDGs.

- The first goal in the 2030 agenda aims to eradicate extreme poverty for all people around the world. Currently, there are more than 800 million people who live on less than 1.25 US dollars per day (UN, 2016). Application of new technologies in developing countries can help build a platform that facilitates online selling of agricultural goods, increasing income revenues of the extreme poor. For instance, Craftsmen in rural China can sell hand-made stage costumes via an online shopping website, Taobao, and significantly increase the income of low-income families in the village (CCTV, 2017).
- Population growth and climate change pose challenges to the production of food for all. New technology application in the agricultural production process brings innovation in farming and helps increase grain yield. Wireless sensors installed in the field monitor temperature, humidity, pest infestation and lower the risks of agricultural production.

[6] Contribution from Government of Bulgaria.

Other technologies such as precision irrigation can help farmers to overcome extreme natural conditions and maximise production of food, which related to the second goal of the Agenda.

- Wearable health and mobile health applications are assisting doctors in prevention and treatment of diseases.
- Technologies are transforming modern education as well. Education institutions are installing ICT facilities in the classroom, and computer-based teaching materials are becoming increasingly popular in many countries. Meanwhile, the internet is providing accessible educational resources to everyday issues, making life-long learning more affordable and convenient.
- Working conditions in the digital age have also improved as technologies lead to the increase of productivity in office work, with the use of computers and other digital technologies. For individuals, digital technologies also revolutionise the style of working: employers can now work from home or arrange virtual meetings with collaborators around the world. Emerging technologies also address challenges at a larger scale.
- Scientific innovations in Big Data, Artificial Intelligence, and the Internet of Things contribute to research and development of sustainable energy. For example, sensors, radar and satellites could collect data about sunlight intensity and wind speed in real time. Algorithms such as machine learning can predict the power generation needs using automatically collected data (Bordoff, 2016).
- Emerging technologies are also applied to mitigate problems in building sustainable cities and communities, where smart cities are designed to optimise transportation networks. In the production sector, technologies such as robotics replace humans in processing chemical or toxic residuals, which ensures responsible and sustainable production.
- Technologies could help achieve other goals in the 2030 agenda, for example, to combat climate change, to conserve the use of marine resources, and to reduce inequalities etc.

Advances in ICTs might create new job opportunities and increase development opportunities in developing countries, but it also requires a skilled workforce to cope with the digitalisation process. Currently, we are facing a mismatch between the requirement for digital competencies and the lack of digital skills among workers in emerging markets. Education programmes and training and digital competencies should be inclusive and accessible to all social groups, as stated in the UN's 2030 Agenda for Sustainable Development, "All people, irrespective of sex, age, race or ethnicity, and persons with disabilities, migrants, indigenous peoples, children and youth, especially those in vulnerable situations, should have access to life-long learning opportunities that help them to acquire the knowledge and skills needed to exploit opportunities and to participate fully in society" (UN, 2015). The same agenda pays special attention to the use of emerging technologies in the empowerment of women, as well as the provision of ICT training in developing countries. Improving digital competencies in the face of the digital revolution might be a recent necessity, but providing knowledge to the society has long been one of the policy focuses. In 2005, UNESCO advocated the development of a knowledge society in which knowledge is a public good, and lifelong education is for all (UNESCO, 2005).

1.3 Digitalisation and the changing labour market

Digitalisation has created new opportunities for the labour market in developing and developed countries. Expansion of the ICT industry has led to an increasing demand for skilled employees in recent years. ICT industries have attracted talents with statistical, computational and mathematical capabilities to work on the development of hardware, software, and applications related to emerging technologies. New job opportunities are also being created in developing countries such as India and the Philippines, where outsourcing hubs have been built, and employees with technical background are hired to support ICT services (World Bank, 2013a). As digital platforms like eBay, Airbnb, Uber, Upwork, and Guru offer more opportunities for micro-entrepreneurs and match freelancers with work, there is also an increase in self-employment and micro-entrepreneurship.

It is important for policymakers to pay attention to the impact of technologies on the labour market because most technological innovations are not neutral. Some are biased towards capital, some favour labour. When technologies favour workers, technology advances are more likely to benefit workers that have skills and disadvantage those without digital competencies. Thus, the result of technology changes might be advantageous to some essential productive factors, and disadvantage other factors. Current technological innovations, such as automation and artificial intelligence, have profoundly improved the value of capital and workers who have relevant skills, for example, employees who master IT skills. From a human capital perspective, such technological innovations are not beneficial to the general workforce. Advances in technologies disadvantage workers with no digital skills or with partial skills since they are involved in repetitive, routine, and regular work. On the one hand, the development of new technologies usually increases the demand for capital and skilled labour. Meanwhile, the demand for labour declines and its value and return shrink, which is the first of the major factors that influence income. On the other hand, the development of technologies also has distributional impact. Value added is created during the production process but it is redistributed afterwards. The redistribution is determined by the percentage of capital and labour in the essential productive factors. The application of new technologies increases the percentage of capital, which leads to fewer redistributions to workers. Therefore, biased and directed technology innovations will exacerbate inequalities in income distribution.

In addition, the development of robotics can also produce negative effects because many workers will lose their jobs if they are replaced by robots. The AI and robotics revolution will not only affect jobs of workers who have low digital skills, but also some highly skilled workers if their tasks are repetitive and mundane, for example, traders in banks, financial analysists, accountants, translators, some teachers, and doctors. Also, different countries vary substantially in the education of digital skills and the availability of ICT infrastructure. Therefore, countries are not equally equipped to take advantage of the opportunities offered by technological changes.

Female workers are particularly impacted by digital technologies. Women are present in some traditional industries such as retail, food, and service, which are facing challenges from increasing automation and are gradually replaced by machines and robots. On the other hand, women are less represented in emerging digital industries and in science, technology, engineering, and mathematics jobs (UNCTAD, 2016). Therefore, technologies are ladders for economic development, but could also be a disruptive factor for future employment.

Economists have warned of the potential increase of unemployment in low-skilled jobs, where workers are losing the competition against machines and computers in accomplishing repetitive and routine tasks. Even cognitive jobs that involve subtle judgement are facing challenges from automation (Frey & Osborne, 2015). 85%-90% of future jobs will require ICT skills by 2020, estimated by the European Centre for the Development of Vocational Training (EU Science Hub, 2013). Approximately 47% of US employment is at risk (Frey & Osborne, 2017). Developing countries may face even greater challenges than the industrialised countries. The World Bank estimates that the share of jobs at risk of automation is even higher in developing countries—77% and 69% of all jobs in China or India, respectively—and perhaps 85% in Ethiopia (World Bank, 2016b). Frey and Osborne (2016) suggest that developing countries can prepare ahead for future changes brought by digitalisation by implementing measures aimed at improving the quality of education and training, fiscal incentives for employment, and protection and subsidies for the vulnerable, among others.

In addition, there is shift in the structure of the labour market with the computerisation of manufacturing industries: although computers and machines displace human labour in repetitive and routine jobs, tasks that require creativity, imagination, communication skills, benefit from digitalisation but still need human employees to supervise, monitor and execute. Such industries include scientific research, management, legal services, financial analysis. For workers who face being replaced by new technologies, they have opportunities to relocate themselves into new industries. But the transition requires acquiring new skillsets that "are uniquely human" (Autor & Dorn, 2013). As a result of failing to update skill sets to cope with digital revolutions, the incomes of workers in many countries stagnated. As machines are taking over more jobs in many industries, there will be an increasing tension between workers who feel insecure with the introduction of robotics and employers who prefer the increased productivity brought by new technologies. Instead of racing *against* machines, Erik Brynjolfsson and Andrew McAfee suggest that low and middle-skilled workers should develop complementary competencies that allow them to race *with* machines (Brynjolfsson & McAfee, 2014).

Developing countries are facing more pressures in equipping their labour forces with digital competencies than developed countries since economic growth in countries such as India and China is partially attributed to the rapid development of manufacturing sectors. The competitive advantages of developing countries in providing cheap labour to assemble products are now challenged by the low-priced industrial robotics. Manufacturing factories in

developing countries increase investment in automation to improve productivity and reduce labour costs. The Chinese manufacturing company, Foxconn, a major supplier for Apple, was reported to replace 60,000 workers with robots (Wakefield, 2016). The cost of installing robots in manufacturing is decreasing. It is estimated that in 15 years the operating cost per hour of a robot doing welding tasks will drop from 8 to 2 US dollars, making them an economical alternative to human labour. This suggests that robotics systems are becoming an economically viable alternative to human labour in more and more industries (Sirkin, Zinser, & Rose, 2015).

The proliferation of robotics in the manufacturing industry will also redefine competitiveness between developing and developed countries. With forward-looking strategies that involve increased investment in research and development on automation and robotics, companies in developed countries could easily regain competitiveness in the 4th industrial revolution. Developed countries have advantages in manufacturing affordable industrial robotics, and enhancing workers' digital competencies by providing on-the-job high-tech training. Developing countries might face an increase in unemployment in manufacturing industries and might lose competitiveness in international trade if the current gap in digital technologies and digital competencies continues to widen dramatically in the future (Sirkin, Zinser, & Rose, 2015).

1.4 New opportunities and challenges for women and youth

The current technological revolution is also accompanied by demographic changes, especially since a more diverse population in the global South is increasingly adopting emerging technologies. The diffusion of ICTs, such as mobile phones, first started with the young, urban, rich and male population, and later was adopted by a more diverse population that includes middle-aged and elderly, rural, and female groups, owing to the decreased manufacturing cost of ICT devices (Aker & Mbiti, 2010). In this section, we will mainly focus on youth and women, to explore how technologies are bringing new opportunities and challenges for them.

As many countries are now becoming ageing societies, improving the education and employment of the young is becoming particularly important in policy-making. Developing countries are witnessing an increase of young people in the labour market. About half a million young Indian and Chinese are joining the workforce in the coming decades. In Africa, it is expected that around 11 million young Africans will to join the labour market every year for the next decade (World Bank, 2016). Technologies are both empowering the youth and displacing them in the job market. On the one hand, ICTs such as mobile phones and computers enable young people to have convenient access to diverse information sources and provide them with platforms to expand social networks, acquire knowledge, and engage in public spheres.

Young people are in an advantageous position, compared to other social groups when adapting to the digital transformation. The multi-media interface on computers and mobile phones allows young people with a lack of traditional literacy skills to understand content on digital

devices and exploit various functions via new technologies. On the other hand, some emerging technologies like Robotics and Machine Learning Algorithms are replacing workers, leading to the shrinkage of blue-collared job opportunities for young people with low or medium educational backgrounds. The competition with modern technologies pressurises the young to enhance their creative, cognitive and critical thinking skills. It also creates pressure on educators and policy-makers to design curricula that equip young people with essential skills in the face of digitalisation and automation in all industries.

Box 3: ICTs and the Gender Gap

Technologies also play an important role in the empowerment of women. In fact, the Sustainable Development Goal (SDG) 5b aims to: "Enhance the use of enabling technology, ICTs, to promote the empowerment of women." Empirical studies found that emerging technologies are empowering forces for women around the world: they provide new channels of communication and increase financial incomes for women, thus empowering women both in the workplace and at home (Khan & Ghadially, 2010). Non-traditional work such as part-time and self-employment in the platform economy, enables flexible working schedules for female workers and creates new working opportunities for women (OECD, 2017). Women also benefit more from the platform economy than their male counterparts. A study shows that more than 73.9% e-business owners on Chinese e-shopping website, Taobao, are females[7]. However, although the uptake of ICTs keeps increasing over recent years, statistics from ITU (International Telecommunication Union) show that the gender gap in internet use increased from 11% in 2013 to 12% in 2016. The gender gap in technology use in the least developed countries (LDCs) is the largest, at 31% (UN Women, 2016). Ownership of technologies is restricted among women: shared use of technology devices is common in developing countries (Doron & Jeffrey, 2013). There is also a gender gap in the use of mobile phones. Reports show that women use mobile phones less frequently and utilise basic rather than more sophisticated services compared to male users (GSMA, 2015). The gender gap is also reflected in the ICT industry, where there are a disproportionate number of female employers. Women account for 31% of Google's overall workforce, and yet only comprise 20% of technical positions (Google, 2017). Female employers only constitute 17% of Facebook's global workforce (Williams, 2016). Lack of female representation in technical and leadership positions in technology companies might have a negative influence on the companies' performance, but more importantly, will hinder the professional development of women.

[7] http://acwf.people.com.cn/n1/2016/0516/c99053-28354273.html

1.5 Summary

Emerging technologies have a profound influence on the way we live, work and participate in society. As technologies advance, new opportunities and challenges emerge, particularly in the labour market. Technologies are empowering employees by providing affordable and convenient access to information, but are also competing against human labour in repetitive and routine tasks, sometimes even replacing human beings in cognitive jobs such as translating foreign languages or diagnosing diseases. Emerging technologies are also changing the global economic dynamics: developing countries are losing their competitiveness in providing low-cost labour in manufacturing with the increasing installation of industrial robotics. Digitalisation and computerisation processes also lead to a shift in employer demographics. Youth and women are particularly influenced by the structural change in the labour market. Young people are adaptive to new technologies but are facing increasingly intense competition from robots, while women are both empowered in the digital era, but the gender gap remains in terms of access to, adoption and use of technologies, as well as in ICT-related industries. Technologies can both become an equaliser of society and a disruptive factor in labour markets. The key strategy to compete with emerging technologies is to enhance people's digital skills and competencies and to equip them with unique skillsets to work and live in the future information society.

Chapter 2. Digital Skills and competencies in the digital era

While new technologies create new jobs, they also create increasing demand for digital skills and competencies. As ICTs advance, digital competencies need to be taught with the same importance as literacy. However, there is a digital skill gap in the workforce: 44% of the European workforce is not equipped with basic digital skills, a report by the European Commission suggested (European Commission, 2014). Graduates with a background in ICTs, for example, computer science, information science, software engineering, cybersecurity, will be in high demand in the job markets. Girls and women are particularly under-represented in Science, Technology, Engineering and Mathematics (STEM) (UNESCO, 2015). Digital competency is an important factor in the creation of the digital divide and thus has a wider impact on individual and social development. Hargittai and Hinnant's research among young adults' online activities found that those with higher levels of education and more resources tend to use the internet for more capital-enhancing activities. They suggest that it is not access to the internet that determines the digital divide, but ICTs user sophistication and digital skills in utilising the internet (Hargittai, 2003; Hargittai & Hinnant, 2008). This chapter highlights skill requirements for future employment, by categorising digital skills needed by levels and sectors. Our units of analysis are not only individuals, but also small and medium enterprises (SMEs), multinational corporations (MNC), and developing or developed countries that face challenges in equipping their workforces with digital competencies.

2.1 Different levels of digital skills

Many researchers point out that policymakers should focus on digital skills or the provision of necessary training on digital competencies since ICTs have proliferated around the world and are being adopted by individual users in their daily lives. For example, Donner's "After Access Lens" addresses the effective use of technologies by people who mainly rely on mobile devices to access the internet in developing countries. DiMaggio and Hargittai, Celeste and Shafer specified five dimensions of the digital divide, among which inequality in the skills that allow people to use technologies is one factor that could potentially exacerbate digital inequality (DiMaggio, Hargittai, Celeste, & Shafer, 2004). There are four different levels of digital skills needed during the process of adoption, use and domestication of technologies: those required to adopt technologies, those needed in the basic use of technologies; skills necessary for the creative use and adaptation of technologies, and skills essential for the creation of new technologies. We further group the four levels of digital skills into two categories: skillsets for all and skillsets for ICT professionals.

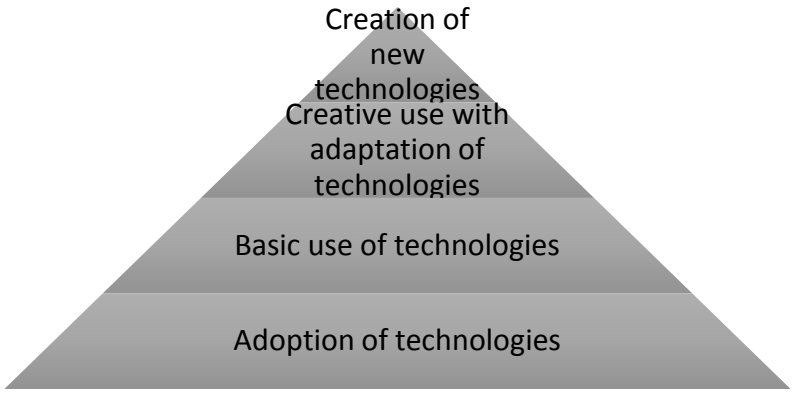

Figure 1: Pyramid of Digital Skills

2.1.1 Digital competencies for all: adoption and basic use of technologies

Skillsets for all include digital competencies for adoption and basic use. The most fundamental skillsets for individuals and companies in the digital era are capabilities to adopt new technologies. A report on UNESCO highlighted the importance of providing "digital literacy for all" to enable every citizen to fully participate in the digital society (UNESCO, 2017). For individuals, this involves basic education and literacy as well as familiarity with technology devices, while for companies this contains knowledge about ICT installations in the existing business system. Significant number of countries have made great strides in attaining literacy. The literacy rate among people aged 15 and above was 86% in 2016, while the literacy rate in the least developing countries was only 60% in 2010 (World Bank, 2017). Having basic education in reading and writing language is fundamental for people in developing countries to use emerging technologies such as mobile phones and computers. However, recent technology innovations in voice recognition, audio-to-text transfer, and voice-controlled

natural language interface help users who lack basic literacy to be able to use technologies such as mobile phones. Nevertheless, restricted by their literacy level, users can only have access to the most basic functions of technologies, failing to utilise rich information resources in their lives.

ICTs also have a vital role in companies. In most developed countries, IT departments have become an integral part of the organisation. However, companies in LDCs still need to develop their knowledge on how to implement new technologies such as robotics in their manufacturing lines, or how to manage the company's human resources using a computational system. After individuals and companies have basic access to technologies, the next steps of digital skills are those that facilitate direct use of technologies, which include a basic understanding of emerging technologies and technology applications, and knowledge about digital privacy and security. For example, individual use of search engines could be enhanced if users understand how these applications collect information across the internet, and how relevant results are ranked and displayed. Learning about the infrastructure of the internet and the role of search engines can provide users of the internet with abilities to actively *pull the* information they need from the internet, instead of passively being receivers and targets of online advertisements (Neuman, 2016). Knowing how technology works and functions can help users to improve the efficiency of usage and to optimise the outcome of using technologies. Another important type of knowledge that is equally important is the knowledge about digital privacy and security, which protect individuals and companies against online fraud or cyber-attacks. With increasing numbers of software and applications are now used to accomplish everyday communicational and informational tasks, basic knowledge of ICTs is now essential for citizens to solve everyday problems as well as engage in community activities (UNESCO, 2017).

2.1.2 Digital competencies for ICT professionals: adaptations and creation of technologies

There are two levels of digital skills that are required for ICT professionals: skills for adaptation of technologies and skills for the creation of new technologies. The third level of digital skills is the ability to innovate based on adapted technologies. This is the level where individuals or companies have already acquired basic computing skills or have hired technical staff that can modify the software or technologies to satisfy individualised needs and requirements. At this stage, individuals or ICT departments within companies understand basic algorithms, and can use online resources to create new functions or develop more suitable applications when needed. Although a degree in ICT-related subjects such as computer science is not required at this level, training in statistics, programming languages, and big data analytics are necessary. Ability to re-design or modify technologies for creative use is also the key for localising emerging technologies in developing countries.

Many of the advanced technologies are designed to be used in contexts where infrastructure, and natural and social resources are different from those in developing economies. To maximise the benefits of new technology, countries and companies in developing countries

need to have the digital skills to make minor or major modifications to new technologies (Huang & Palvia, 2001). Manufacturers and providers of new technologies in developed countries, of course, could offer help by providing digital training when necessary. Creation of new technology is the final and the most advanced level of digital skills. Individuals who have sophisticated programming skills or companies that have talents with knowledge of complex algorithms such as machine learning, will have the capabilities to contribute to the creation of more advanced technologies or the development of technology innovations. Obtaining sophisticated programming skills and acquiring knowledge about complex algorithms are part of professional training in ICT-related degrees. Nevertheless, as new technologies are increasingly adopted by traditional industries such as medicine, finance and journalism, employees in traditional industries also need to combine their professional training with technology skills.

Table 1 Categories and levels of digital skills

Category	Levels	Skills
Digital Skills for All	Adoption	Basic education and literacy; Familiarity with technology devices and services;
	Basic use	Basic understanding of technologies, software and applications; Knowledge of digital privacy and security
Digital Skills for ICT professionals	Creative use of adaptations	Basic computing skills; Familiarity with basic algorithms
	Creation of new technologies	Sophisticated programming skills; Knowledge of complex algorithms

2.2 Digital competencies for future employment

New technologies bring new opportunities and challenges for future employment. As discussed in Chapter 1, digitalisation complements as well as replaces human labour. It is therefore significant for individuals, governments and companies to prepare the workforce for the digital world. This requires, at least, three different types of digital competencies: technical and professional, generic ICT skills, and ICT complementary "soft skills" (see Table 2). It is important for policymakers to identify the types of competencies required because they require unique training programmes and specific resources.

Table 2 Types and examples of digital competencies

Types (OECD, 2016)	Examples
Technical and professional skills	Installation and operation of robots;
Generic ICT skills	Understanding, use and adoption of technologies; Life-learning ability to adapt to technology changes
ICT complementary "soft skills"	Creativity; communication skills; critical and logical thinking; teamwork; digital entrepreneurship

2.2.1 Technical and Professional skills

Technical and professional skills are those directly related to the operation of industrial technologies, for example, how to install and operate industrial robots, or how to interpret received codes on the interface display. Skills under this category are specific and often industry-specific. While the future workforce needs to take related training to be able to acquire professional skills, current workers can also learn about professional skills on the job. In fact, workers who are facing being replaced by industrial robots could update their skillsets by taking on-the-job training and eventually become human operators or supervisors of industrial robots. Workers who are equipped with technical backgrounds in training programmes understand how robots work and have the skills to train robots to accomplish tasks, to detect systematic errors or to facilitate inter-departmental collaborations.

2.2.2 Generic ICT skills

On-the-job training programmes could be extremely hard to be utilised and understood by workers if they lack basic training in generic ICT skills. There should be sufficient courses, programmes and resources available to everyone in society that will enable all individuals, before entering the future job markets, to gain skills to understand, use, and adopt new technologies. One of the technical skills that only recently drew the public's attention is life-long learning ability. The speed of technological innovations is still accelerating, and the best way to avoid being left behind by new technologies is to develop the ability to continuously learn. Teaching young people about the ability to cope with emerging technologies is particularly important. Since they might face challenges of more advanced technologies in the later stage of their lives, learning about how technology innovations develop, and the direction of future technological changes will help them to be prepared for changes in employment trends produced by disruptive technologies.

2.2.3 ICT complementary "soft skills"

Finally, there is an increasing demand to build unique human skills that cannot be replaced by machines, computers and robots. Research shows that occupations such as engineering and science are less susceptible to digitalisation and computerisation because these professions involve a higher degree of creativity and innovations compared to other jobs (Frey & Osborne, 2017). Occupations that involve sophisticated communication skills are also in a more secure

position in the digital era. For example, natural language processing algorithms can detect emotions underlying text, but are often inaccurate in comprehending sarcasm, humour or irony. When equipping a future workforce with complementary "soft skills", it is also important to develop critical and logical thinking abilities, which are vital when preparing young people with abilities in problem-solving and decision making. With the increase of the platform economy, soft skills for digital entrepreneurship are important for individuals to benefit from the digital economy. Many countries have highlighted the importance of providing related training on e-business: Turkey aims to increase the percentage of individuals with entrepreneurship training from 6.3 in 2012 to 15 in 2018[8].

2.3 Digital competencies for different economic structures

While education and training programmes that focus on digital skills for all, including training on the adoption and use of technology, need to be inclusive and accessible to everyone, the needs for other types of digital competencies vary across sectors, countries and level of industrial development. In countries where technology development remains in its early stages, basic technical skills and generic skills are the most required. Meanwhile, international assistance is necessary to provide infrastructure and technology services. Once users and companies have adopted and mastered locally available technologies, then more sophisticated professional skills and ICT complementary "soft skills" become important to enable local innovation based on incorporated technologies. After the country has gradually developed familiarity with technologies and has established technology sectors, then it may require more advanced digital competencies to become a supplier of technologies and services to other developing countries. The need for technology skills and policy interventions should be both selective as well as functional to maximise the outcomes of industrialisations (Lall, 1992).

Box 4: ICT skills and agricultural development

One of the factors influencing the type of digital competencies needed in countries is their economic structures. In a country where agriculture is the dominant industry, basic digital literacy of new technologies like mobile phones is essential. Fu and Akter's empirical research in rural India demonstrates that the abilities to use agricultural services on mobile phones can improve farmers' agricultural knowledge. While education on basic ICT use facilitates rural development for these economies, digital skills for ICT professionals to modify emerging technologies into creative use are equally important. For example, the mobile technology used in rural India is created around local issues and knowledge. The creation process requires talents who are equipped with more sophisticated digital skills to contribute to the making of content (Fu & Akter, 2016).

Countries where the manufacturing sector dominates economic growth will require talents, experts and a workforce with specialised skills in industrial robotics, automation, and the Internet of Things. As requirements for labour declines, workers need to receive on-the-job

[8] Contribution from the Government of Turkey.

training and programmes as soon as possible, to minimise the risks of being displaced by machines. Skills that enable workers to work with new technologies are increasing, and thus certain complementary soft skills are also needed in the digitally transformed manufacturing industry (The National Academies of Science, 2017).

In countries where service industries, including tourism, financial, and healthcare services, are prosperous and growing, there is a higher demand for sophisticated and specialised digital competencies. For example, in the financial sector, technologies are transforming business models and creating new business opportunities. Technologies such as mobile banking, are bringing financial inclusiveness to populations that were previously lacking financial services. Financial services need skilled employees with technical training backgrounds to adapt to the changes by adopting artificial intelligence and big data analytics into the system to improve the efficiency of services. Meanwhile, new technologies such as blockchain are transforming the way financial infrastructures are designed and used (Marr, 2017; PwC, 2016). Adoption of new financial technologies requires experience and knowledge of the systemic model, numeracy skills and computational competencies.

2.4 Summary

This chapter has highlighted the digital skills' requirements for future employment. Digital competencies are significant to prepare individuals, companies and countries to maintain sustainable development in the digital era. Four types of digital competencies that are crucial for individual, corporation and national development are identified: skills in the adoption of technologies, basic ICT use, creative ICT use with adaptations, and creation of new technologies. Different types of skills required for future employment, namely technical and professional skills, generic ICT skills and ICT complementary "soft skills" are also analysed. Finally, different skills needed in countries with different economic structures are explored.

Chapter 3. New Technologies for Digital Competencies

3.1 Using digital technologies to build and enhance digital skills

New technologies have accelerated the speed of information flow, extended the scale of knowledge exchange, and digitalised educational materials. Traditional teaching curricula and training programmes can contribute to the enhancement of digital skills; meanwhile, technologies such as computers, mobile phones, the internet, virtual reality technology, can also play key roles in the acquisition of digital competencies. The proliferation of ICTs is taking place in both developing and developed countries. The decreased costs of technology devices, improvement of technology infrastructure, and international assistance all contribute to the increasing use of digital technologies to build and enhance digital skills. Compared to traditional training models and methods, digital technologies enable interactions between

trainers and students, provide multi-media interfaces that facilitate learning, and are flexible in relation to where, when and to whom can be educated. We identify four trends of digitalisation and computerisation in the education of digital skills: technology-mediated learning; Massive Open Online Courses (MOOCs), Open access to scientific literature, and scale education using the internet.

Table 3 Trends and examples of digitalisation in the education of digital skills

Trends	Examples
Technology-mediated teaching and learning	Internet resources and adaptive assessment system for teachers; ICT facilities in classrooms ICT for remote learning and life-learning Platform for teacher-student interactions Assistive technologies for individuals with disabilities
Massive Open Online Courses (MOOCs)	MOOCs for higher education (Coursera, edX, and Khan Academy) MOOCs for vocational training (Alison)
Open Access to Scientific Literature	Open access journals and databases (PLOS) Traditional publishers open to developing countries (PNAS) Self-archiving websites (arXiv)
Scale Education Using the Internet	Media centre and remote learning

3.1.1 Technology-mediated teaching and learning

ICTs such as computers and mobile phones can become the platform for teaching and learning. Implementing education technologies in schools can change how pupils and teachers education strategies time at school. For instance, AI allows machines to learn about pupils by studying the data produced in the education process. This allows the customization of educational programmes according to the pupils' strengths and weaknesses (Economist, 2017). Digitalisation in teaching can also help educators to collect and synthesise data about students' performance and learning progress. Using artificial intelligence and data analytic approaches, researchers from education and other disciplines can work collectively on the improvement of education technologies. New technologies are also changing the way teachers make assessments or provide feedback by, among others, producing intelligent scoring, interpreting of individual profiles, and providing advice to learners and teachers by inferencing procedures (Redecker and Johannessen, 2013). Assessment of performance is therefore real-time, flexible, and embedded in the teaching process. Further, technology such as virtual reality or speech recognition and generation applications can create a virtual learning environment for students to learn. Virtual tutors created in these environments can also assist students to learn a language, maths or science through interactive teaching or games.

Students can also use education technologies for effective learning both in classrooms and at home. ICT facilities are now widely used in teaching. Tablets, which are sometimes preferable

to computers due to their portability and affordability, are adopted as a complementary teaching device and could be taken home by pupils (Coughlan, 2014). Digitalising students' learning experience will improve the presentation of educational materials, including documents, images, and mathematical functions, and make the learning process more interactive, compared to traditional teaching approaches. Introducing new technologies to students in primary or middle schools also helps students to acquire basic ICT literacy:

- Digital skills such as reading and editing digital documents, browsing the internet, and searching for information online, are required for the jobs of the future.
- ICT also enables remote and life-long learning. Schools that use online learning platforms could share learning materials in the forums, allowing students to study remotely at home.
- Technologies also break the institutional boundaries of schools, colleges, and universities: people who want to continue their study could use e-learning platforms. E-environment could also be part of administrative processes in higher education institutions. For example, higher education institutions adopt the platform Moodle[9].
- Information shared on the internet also enables individuals to find useful resources that assist in their self-learning.
- Also, technologies make education resources accessible for the disabled. For example, text-to-speech can translate printed books and articles for visually impaired students.
- Software designed to train reading skills could help students with reading disabilities. Assistive technologies, for example, screen readers, alternative keyboards, and refreshable braille displays can help individuals with disabilities to use ICTs[10].

3.1.2 Massive Open Online Courses (MOOCs)

Massive Open Online Courses (MOOCs) exemplify how ICTs transform the way we learn. MOOCs consist of open platforms where students could take courses, read materials and engage in online discussions. They have been widely used by the public when online platforms and websites such as Cousera, edX and Khan Academy appear. Although courses are organised in ways that are similar to traditional offline teaching programmes, students do not need to register with schools or universities to learn, and they can take self-paced courses. MOOCs represent a new way of life-learning: individuals can choose any subjects they want to study and acquire knowledge from courses that are provided by professors and institutions of world renown. Driven by students' need for digital skills, many courses on MOOCs focus on subjects that help develop professional ICT competencies, for example, advanced statistics, machine learning, computational languages, and data visualisation. Soft skills such as communication, personal development, and time management are also popular courses among students of

[9] Contribution from the Government of Latvia.
[10] Contribution from the Government of Canada.

MOOCs. As digitalisation begins to influence the job market for low and medium-skilled workers, there is an increasing need for MOOCs that could provide vocational courses that teach technical or professional skillsets in increasing demand due to technological changes such as technical skills like web design and online business management. MOOCs are making higher education and professional training accessible to everyone, and are providing future employers with more talented or skilled workers who have self-trained online.

3.1.3 Open access to scientific literature

Creation of new technologies requires the exchange of information and knowledge worldwide. ICTs have already accelerated the process of publishing scientific literature, and yet open access databases and journals of scientific literature are providing scientific knowledge to internet users around the world. On the one hand, open access publishers such as Public Library of Science (PLOS), distribute digital copies of research articles online and provide open access for the public (PLOS, 2017). Traditional scientific publishers are also helping to make science accessible in developing countries (PNAS, 2017). On the other hand, scientists are increasingly using archiving websites to share their research with a much wider audience. Accessible scientific knowledge online allows researchers and students around the world, particularly in developing countries, to keep up with advances in technology innovations and to contribute to the accumulation of scientific knowledge.

3.1.4 Scale-up education using technologies

In many developing countries, the lack of teaching staff in remote areas is one of the barriers to education. Internet access can help mitigate this issue by providing high-quality learning materials accessible to teachers and pupils in the least developed countries and regions. In remote villages where there are only very few students, media centres could become educational institutes that, in addition to provide education, can also track and assess the performance of students. For example, a media centre in Brazil helps children in remote communities to continue schooling. The centre provides technologies and complementary human interaction: while a bi-directional camera enables teachers to interact with students remotely, a tutoring teacher supports the students' learning by helping manage classes and handle administrative issues (Robinson, Winthrop, & McGivney, 2016). Students in the media centre system in Brazil benefit from technological advances, as remote learning has become a more interactive and engaging experience. Box 5 describes the case of Latvia as an example on how ICTs are addressed in policies associated to the processes of learning and development.

Box 5: Latvia's Guidelines for the Development of Education for 2014-2020[11]

[11] Contribution from the Government of Latvia.

The Guidelines for the Development of Education for 2014-2020 is the main education policy planning document in Latvia. It addresses the use of ICTs in the processes of learning and development of digital skills with the support of the state budget and the EU financial instruments. The development of digital skills is very important for Latvia. It allows to promote the quality of education and to broaden education opportunities for all groups, as well as to react to the continuous transformations of the labour market. Some of the initiatives considered in the Guidelines include:

- On-going development of competency-based general education content, including promotion of digital skills and digital learning materials;
- Professional development of teachers, strengthening of their digital skills and the ability to use them in the classroom while working with students with different backgrounds;
- Upgrading of the infrastructure and learning environment, providing tools for the effective use of ICT;
- Facilitating mutual cooperation of teachers, including within E-Twinning network, supporting innovative ICT solutions in the learning process;
- Supporting STEM (Science, Technology, Engineering, and Mathematics) and attracting more students to these study directions;
- Ensuring sustainability between different stages of education and coordination of the plan of acquisition of digital skills with universities.

Technology has mediated new ways of teaching and learning and has also created new opportunities for enhancing digital competencies for women and youth. ICTs such as online business platforms or social network tools have empowered women in developing countries by offering them access to business information or convenient communication tools. However, restricted access to ICT and lack of digital training may hinder the digitalisation process among the female population. In Bangladesh, a group of Info-ladies, women who have received training in using laptops, mobile phones, and various internet applications, help villagers to make Skype calls with their families, test blood pressure, or even give legal advice (ITU, 2014). Training programmes like Info-lady empower women by providing them with knowledge about ICTs, making specially trained women information mediators between the villagers and the world.

Technologies also enhance the business and professional skills of young people. E-commerce websites such as eBay or Taobao enable young people to run micro-entrepreneurship online. Open access training programmes on e-business, financial markets, and internet skills help to equip the youth with relevant competencies to achieve success in their careers. On-the-job training on digital competencies also helps young workers to adapt to new changes in the digital era. The National Citizen Service (NCS) in the UK aims to help young people to develop digital skills such as coding, by adding high-performance computers into the programme (Department for Digital, Culture, Media & Sport, 2017).

3.2 Existing technology gaps in the education and learning of digital competencies

Improving digital competencies using ICT is both efficient and affordable; however, people living in developing countries can barely enjoy the benefits of technology-assisted training on digital skills due to the existing gaps in infrastructure and equipment, software and platforms, and teaching staff and resources.

3.2.1 Infrastructure and equipment

Training on digital competencies has a relatively high requirement for well-established ICT infrastructures such as broadband and 3G or 4G mobile network, and for ICT equipment such as computers, tablets, and mobile phones. The availability of ICTs varies in developing and developed countries and is reflected in ICT facilities in schools. 90% of students reported having access to the internet at school, according to an OECD report (OECD, 2017). Technology infrastructure in developed countries has a profound influence on the improvement of students' digital competencies; statistics suggest more than half of the students in OECD countries can use information on the internet for homework, indicating their familiarity with information technologies such as search engines. In contrast, developing countries often lack ICT infrastructure in primary or secondary schools. Internet coverage at school falls below 20% on average in developing countries (ITU, 2014). Blackouts and poor internet connections during digital skills training sessions are also common in the least developing countries. ICT development is different between rural and urban areas in the same country. Urban schools are often equipped with better broadband coverage and have faster internet speed than rural ones. Private schools that have more funding resources tend to use more advanced technologies in teaching programmes of digital skills.

Meanwhile, there is also an infrastructure gap between technology adoption at home and in the classroom. While families and individuals widely adopt ICTs, reports suggest that schools lag behind in the adoption of new technologies: 96% of students in OECD countries have computers at home, but only 72% reported using ICTs at school (OECD, 2017). This gap between school and home use of ICT is wider in developing countries where villages and local communities have shortages of public ICT facilities. Lack of access to digital technologies at home might undermine how much students can learn from digital skill training. To narrow the technology gap at home, countries could build information centres that are equipped with ICT facilities in local communities, or could provide affordable mobile technologies such as tablets to low-income families. For example, a public-private collaboration in the United States of America, ConnectHome, provide free or low-cost broadband access, device and digital literacy training to low-income families, aiming to narrow the digital divide at home[12].

[12] Contribution from the Government of the United States of America.

3.2.2 Teachers' knowledge of ICT and online resources

Teachers in developing countries lack digital literacy compared with their counterparts in developed countries. Unlike traditional subjects, teaching digital skills requires special pedagogical approaches. For example, ICT tutors and teachers need to learn not only how to use technologies but also how to improve the efficiency of using technologies. Knowledge on the structure and foundation behind new technologies also helps in the teaching process. However, there is a lack of teachers' use of digital media to present teaching materials, to assist in students' assessment, and to deliver digital competencies' training. Noticing the gap in teachers' knowledge of ICT, many projects that aim at improving education in developing countries emphasise teacher training in digital competencies (Ericsson, 2013).

Current software and platforms developed for digital skills' learning are predominantly designed for social and cultural contexts in developed countries. More open sourced software and online platforms need to adapt and be localised to fit into classrooms for students in developing countries. Also, teachers and trainers of digital competencies in developing countries need more open access learning materials to support their teaching. Existing training courses online need to be restructured or edited to be more adaptable to digital skills' learning in developing countries. Translation of content is also necessary when teaching digital skills to some indigenous communities. Such training programmes also need to integrate content relevant to the traditions, culture, and history of the local community to facilitate efficient ICT learning (Eady, 2015).

3.3 Summary

In this chapter, we focus on the potentials of ICTs to foster the teaching and learning of digital competencies. Emerging technologies can be both the platform of digital skill training, and can provide open access to learning materials or scientific knowledge for students and teachers. Technologies also help developing countries to scale up education and provide remote education in isolated communities. By using technologies, women and the young generation can develop digital skills or receive vocational training, which can help them to seise new opportunities in future employment. However, there are gaps between developing and developed countries in ICT infrastructures, teachers' knowledge of ICT, and online resources, which has hindered the progress of digital competencies' training programmes in developing countries.

Chapter 4. Policy considerations

Preparing societies with adequate digital competencies to understand, adopt, use and create new technologies, particularly ICTs, is key to sustainable development in a digital world. Abilities to utilise technologies to mitigate problems encountered in life and work are essential for people's wellbeing and success. However, the uneven distribution of digital competencies and access to new technologies between regions and groups hinder the capacity of countries to

leverage technology for development. Even within a country where new technologies are widely adopted, there are still gaps between social groups on how familiar they are with new technologies, and whether they can efficiently use new technologies in a problem-solving processes. Therefore, both developing and developed countries need to emphasise the improvement of digital competencies in national policy and strategy.

A number of policy and strategy considerations could potentially assist countries in their efforts to build digital competencies as part of science, technology and innovation-led strategies for sustainable development.

4.1 Building digital competencies through education

Although digital skills can be improved as users become increasingly familiar with technologies, education, including formal or informal education and training, are crucial in prepare the workforce and the society with the skills that can effectively use the available digital technologies. They are also essential for our ability to innovatively use digital technologies or to create new ones. Some digital skills, for example, sophisticated coding and database management, can only be learned through professional training. Education policy needs to accommodate new requirements for digital skills' training schemes, making delivery of digital competencies part of the education goals. Depending on the type of skills needed to improve, there are three ways policymakers can improve the teaching and training of digital competencies: incorporating digital skills' training at school, providing digital skills' training for the labour force, and embedding digital skills' training in lifelong learning.

4.1.1 Incorporating digital skills' training at school

Education policies need to emphasise the importance of providing digital training to both students and teachers in primary and secondary school. We have reviewed previously that many teachers still lack digital competencies to either use new technologies in their teaching or provide training sessions on ICT to students (Ericsson, 2013). It is crucial for policymakers first to provide professional development programmes for teachers that focus on improving their digital skills in understanding and using new technologies. Listing digital competencies as one of the learning objectives in schools is also necessary. Currently, courses on literary and numeracy skills account for most students' learning time at school. Students need to spend more time on developing knowledge and skills in the use of new technologies to cope with digital changes.

As more advanced technologies such as Artificial Intelligence are widely used in our society, ICT courses at primary and secondary school also need to adjust their focuses. From teaching students simple operations of desktop computers and text processing tools, to more rigorous courses that teach students to understand fundamental computing languages, and establish their algorithmic thinking skills. Developed countries have been pioneers in revolutionising ICT courses at school. For example, the British government introduced a new ICT curriculum that

includes writing basic computing language and understanding how computers work in 2013 (U.K. Department for Education, 2014). The new curriculum replaced the previous one, adding digital skills that are more desirable in future employment. Initiatives in education are also related to promote safe Internet use. For instance, through workshops to children in schools, Poland's education campaign "My smartphone, my little world-I click sensibly" aims at teaching children how to use the Internet in a safe and creative way (see Box 6). Meanwhile, governments could promote the teaching of STEM, especially for women or other underrepresented groups. The government of Canada is investing in digital skills through the Innovation and Skills Plan, which will equip school-age youth with sufficient skills for the digital future[13].

Box 7 describes options to increase the participation of women in technology positions through education.

Box 6: Poland's education campaign: "My smartphone, my little world-I click sensibly"[14]

The Internet is a source of knowledge, fun and communication. Young people live in a virtual world. Sometimes the boundary between the virtual world and the real world is blurred. "My smartphone, my little world-I click sensibly" education campaign is a response to the ever-growing scale of the threats faced by an increasing number of young Internet users. The training is delivered to children in primary schools by employees of the Office of Electronics Communications (UKE) and is aimed at teaching young users:

- how to use smartphones and tablets more safely;
- how to deal with hate speech on the Internet, how to respond to cyberbullying;
- how to protect their personal information;
- how to avoid high bills to be paid by parents (for data transmission, premium rate services);
- how to creatively use new technologies.

The campaign is conducted throughout Poland. UKE's experts have already visited dozens of schools and they expect to conduct workshops for 40,000 pupils in 2017 and to train 300,000 children by 2021.

Another aim of the campaign is to shape appropriate attitudes among teachers, parents and guardians responsible for access of minors to the Internet. This is done through workshops for parents and teachers.

[13] Contribution from the Government of Canada.
[14] Contribution from the Government of Poland.

Box 7: Initiatives to increase the participation of women in technology positions through education.

The lack of representation of women in technology positions needs to be addressed by designing special programmes for young female students or girls to encourage them to major in science, engineering, and technology. Primary and secondary schools in many developed countries have already realised the gender gap in the technology industry and design courses or facilitate clubs to help girls build confidence in learning technologies. For example, after-school clubs like TechFuture Girls in the UK create a space where female students learn about algorithms or other ICT related skills. More importantly, digital competencies curricula help female students to build their confidence in learning technology skills (TechFuture Girls, 2017). Female students or women in developing countries could also benefit from digital competencies' training provided by non-profit organisations or government.

In 2017, Canada launched a national social media campaign to encourage young women to enter STEM fields, Choose Science. When women, along with those who are otherwise under-represented in labs across the country, make the choice to join science, they bring a diversity of perspectives that enrich the research environment, and the overall research community will become a more inclusive and welcoming place to work.[15]

While students living in developed countries will enjoy an updated ICT curriculum that involves Artificial Intelligence, Robotics, and 3D printing, it is important that students in the global South also have access to digital skills' courses. For developing countries where there is a shortage of ICT infrastructure or facilities, or where electricity or internet connections are often unstable, complementary ICT facilities such as tablets and mobile phones are necessary to support the teaching of digital competencies. In many developing countries, the uptake percentage of mobile phones has already leapfrogged analogue ones. These devices have become the primary device for accessing the internet in people's everyday lives, and yet users seldom use mobile phones in productivity scenarios such as job seeking or online learning (Donner, 2015). Therefore, schools in developing countries need to adopt ICT curriculums that consider not only the mobile internet for information seeking, self-development or social networking, but that also train students mobile internet in activities that foster personal development. Schools in developed countries also need to restructure their ICT training schemes to include mobile technologies with the purpose of improving students' capacity to use these technologies for productive activities. For LDCs, where internet connectivity is relatively low, policy-makers need first to develop infrastructures that support ICTs. Meanwhile, schools in these countries need to provide students with printed materials on digital technologies and skills, and use pre-downloaded digital libraries in teaching digital skills. Even though internet access may still be largely inaccessible to students in LDCs, sufficient training

[15] Contribution from the Government of Canada.

on digital competencies can make sure they will not be left behind and that they will be equipped with the ICT skills that would enable them to not only access the Internet but also make productive use of technologies.

It is important to note the potential of non-formal education initiatives that can also contribute to the development of digital competencies. For instance, CoderDojo Bulgaria by the Digital National Alliance and Partners, is a global network of free volunteer-driven programming clubs for children. The initiative allows children and young people between the ages of 6 and 16 to learn, using mentor volunteers, how to program and create websites, applications and games to explore the possibilities of technology. This initiative does not aim to make every child a programmer but to develop its digital skills through non-formal education. The first two workshops involved more than 50 children being guided by 30 mentors - volunteers. The main goal is to create Dojo workshops in schools in the country where children can develop their skills and increase their curiosity about technology. [16]

4.1.2 Providing digital skills' training for the labour force and life

Providing digital skills training at primary and secondary schools ensures basic digital competencies for everyone. However, even in the most developed countries, many young people might drop out from high schools or not attend higher educations after graduating from high schools. Introducing professional digital skills' training in vocational schools can help young people seise new opportunities offered in the future job market. Programs that aim to improve coding, data analysis and e-business skills in professional and vocational education will help young people acquire digital skills. For example, Ada, the UK's national college of digital skills, provides digital skills' training to students, with a special focus on female students and those who come from lower-income backgrounds[17]. In the provision of digital skills in vocational education, schools need to work closely with industries to update the content of curricula and courses, since technologies advance at an exponential speed and workers in the industries need to upskill constantly. When it comes to highly professional digital skills, experts and talents who have sufficient experience in the industry also need to participate in the teaching of digital skills in vocational training programmes. Some technology companies already realise the importance of knowledge sharing in digital skills' training: IBM has supported the digital skills' training and knowledge delivery in a new form of high school called Pathways in Technology Early College High School (P-TECH) in New York City since 2011. The P-TECH school helps supply technology companies with skilled technology workforce through intensive training programmes. Technology companies can not only train staff and deliver courses, but can also provide opportunities for students to learn digital skills through internships, which help students to enhance their digital competencies further. Most

[16] Contribution from Bulgaria.
[17] Contribution from the Government of United Kingdom.

importantly, digital skills' training in high schools or vocational schools will include students from a more diversified background, regardless of their family income or previous academic performances.

In addition, it is important to also support firms, community school and civil society organisations working on the provision of training of broad skills to existing workforce and the population. This should include broad skills for digital competencies including basic ICT skills for work and for wide social life, life-long learning capabilities and entrepreneurship skills.

4.1.3 Embedding digital skills in lifelong learning

The disruptive nature of digital technologies has already threatened the jobs of low or middle-skilled workers across many industries. Therefore, policymakers, as well as employers, have an urgent need to provide on-the-job digital skills' training to current and future workforce to help them to upskill and extend digital competencies. Institutions that facilitate life-long learning of digital skills are also necessary to make sure there are sufficient infrastructure, hardware, software, and training staff, to help adults enhance their digital skills. Since technologies advance at an unprecedented speed, digital skills' training programmes in these learning centres need to constantly update to provide the most important professional skills for adult students.

It is important to note, however, that lifelong learning may not necessarily mean upgrading skills but just updating skills to do the tasks (non-routine manual and cognitive) that may be left to humans. However, determining the types of skills to develop will ultimately depend on foreseeing the jobs or tasks that will still require human labour in the automation process. What becomes relevant is to think in terms of skills, and not so much about jobs, and matching those skills to the needs of the labour markets. The term "learnability" – the desire and capability to develop in-demand skills to be employable for the long-term – has recently emerged to describe the key attribute that employers demand in an environment of rapid technological change.[18]

Traditional community centres such as libraries could provide new training programmes for members of the community. For example, public libraries in Bulgaria have provided digital skills' training for various social groups, which is also part of Bulgarian's National Strategy for Lifelong Learning (2014-2020)[19]. It is also necessary to fully exploit the potential of digital technologies such as social media and MOOCs in lifelong learning and on-the-job training. In China, social workers use WeChat, a social networking application on mobile phones, to teach basic digital skills for the elderly living in the village (Xiaojing, 2017). MOOCs could also be

[18] Article by Mark Swan, Executive Vice President, Global Strategy and Talent, Manpower – 'These skills could save your job – and your company', 31 August 2016, in World Economic Forum. Available at https://www.weforum.org/agenda/2016/08/this-little-known-skill-will-save-your-job-and-your-company/

[19] Contribution from the Government of Bulgaria.

the online forums for learning digital skills. Currently, many MOOCs are backed by higher education institutions to provide advanced courses such as machine learning or big data analytics. The MOOC platforms have enabled self-paced lifelong learning, and students' certificates of completed courses are increasingly recognised by employers. Nevertheless, MOOCs could also be used to support on-the-job training and life-long learning by providing more practical and industry-related courses for workers. The new employment-oriented MOOCs can offer learning opportunities for workers who cannot attend offline courses or whose free time for learning is relatively fragmented. Box 8 illustrates initiatives aimed at provide digital skills to young people.

Box 8: Vocational and on-the-job training focused on digital skills for young people

Young people who do not attend universities or drop out from school early can benefit from vocational and on-the-job training that focuses on digital skills. While some courses focus on practical skills such as website development, it is equally important to develop "soft" skills such as logical thinking through training. Vocational training that specifically focuses on young people should have both a short-term focus on immediately needed skills and include skill training that helps young people develop a better understanding of trends and foundations behind emerging technologies. For example, the "Industry 4.0" project in Turkey aims to provide young students in vocational schools with skills' training and knowledge in emerging technologies such as the Internet of Things[20].

Another special programme that might help prepare the youth for the digital revolution is training on digital entrepreneurship. Young people are less risk-averse and find it easier to learn new skills. This means that they have the potential to build their own start-ups in the digital future. It is necessary to provide young people with training programmes that help them learn about e-commerce, online business platforms or online advertising. Many technology companies have provided such training online. For example, Intel has a course entitled "Technology and Entrepreneurship" as part of its learning programmes for people under 25 years old (Intel, 2017). Similar courses should also be included in vocational training to help young people seise new business opportunities.

As digital technologies become increasingly important for both employment and everyday life, women in developing countries require basic digital literacy to either compete with male workers in the job market or to manage everyday household tasks. A project named the Citizens' Foundation has conducted an assessment of women's digital educational needs and also developed an online platform to facilitate literacy education for women living in rural Pakistan (UNESCO, 2017). For women in developing countries, basic internet connectivity needs to be provided by the government to meet their ICT needs. The government of Kenya aims to provide internet access to local communities, which will include women and the disabled[21].

[20] Contribution from the Government of Turkey.
[21] Contribution from the Government of Kenya.

The private sector also has an important role to play in developing lifelong learning opportunities. Companies should deliver corporate training programs, sponsor their employees to re-train and allow for time flexibility for workers to be able to take part in re-training courses, and this should be incentivized by governments. Increased connection between the education system and the workplace is another key element in lifelong learning because many of the necessary skills are further developed on the job.

There is no one-size-fits-all or single recipe for education and lifelong learning policy as it is important to consider the different circumstances of the countries in terms of the level of development and industrialization, skills needs as well as levels of education and training capabilities.

4.2 Creation of an enabling environment through investment in infrastructure, institutional development and entrepreneurship

While direct interventions through education and training are critical for the development of digital competencies of the workforce, the creation of an environment that nurtures digital competencies of a country indirectly through investment in infrastructure, institution development and entrepreneurship is also crucial.

4.2.1 Investment and development of digital infrastructure

Data will become the most important resources in the world in the digital era. An important element of digital competencies of a country is the digital infrastructure such as data resources and the facilities and capabilities in collecting, analysing and using big data. The later includes the facilities in data collection, data storage and data analysis such as the sensors system, 5G network, icloud facility, high capacity computing equipment. This includes building national big data centres, realise full broadband coverage in developing countries, and regional high-speed computing and processing facilities for big data analysis.

Investment in infrastructure should also consider investment in big data analytical abilities and in making effective use of them for economic and social activities, and public administration. This type of investments includes: online platforms and education apps to enable countries to use ICT to educate and train workforce and citizens, and investment in data resource capabilities building, including facilities for data collection, storage, transmission, and analysis as well as and capabilities to integrate results for policy making and business decision making.

4.2.2 Development of institutions and environment to nurture digital competencies

The development of digital competencies also requires the presence of appropriate institutions that set rules that promote investment in competencies and creation of incentive structures that motivate workers, management, firms, universities and other organisations to adopt and develop the skills needed. These institutions include laws and regulations, organisations such as vocational schools and community schools that support professional training and lifelong

learning, university departments and centres conducting research and develop digital technologies and their applications, NGOs and social organisations that provide support to the wide society for digitalisation and adoption and use.

In addition to institutions discussed, culture and entrepreneurship are also some of the essential aspects to be considered in the development of digital competencies, especially in the emerging technology-intensive new economy and in the informal sector. This wave of digitalisation brings about fundamental changes to the way production is organised and how value is created. Digitisation connects individuals and enables them to be included in the economic system as value creators, intermediaries—such as traders—or even platform providers. Therefore, to develop an environment and culture that encourages entrepreneurship is also essential for a country to seise the opportunities brought through by this technological revolution. Other efforts in areas such as taxation, financing, industry and labour market policies can also help to develop an incentive structure that encourages and facilitates investment and labour participation in the digital economy, for example, tax recession, low-interest rate bank loan, digital small and medium enterprise support (SME) support funds, and special human resource or migration policies for digital talents. Box 9 identifies selected national strategies aimed at providing an enabling conducive to take advantage of the developing opportunities offered by new technologies, including advances on ICTs.

Box 9: Selected national strategies aimed at increasing digital competencies of countries

- Digital Uganda Vision: Addresses issues related to infrastructure support, policy framework, access to the ICTs, capacity development, collaboration amongst various agencies, common access of government services by citizens, delivery of services, and participative access. [22]
- Kenya's Information and Communication Technology Master Plan: This is roadmap based on the ICT theme "strengthening the foundation for a knowledge-based economy". It considers strategies to enhanced public value, development of ICT businesses, and strengthening of ICT as a driver of industry.[23]
- Digital Bulgaria 2020: Sets forth the current priorities of Bulgaria in the global process of digitalization, including bridging the digital divide, increasing digital literacy and competencies of individuals, and reducing the shortage of highly-qualified working hand in the high-tech sector.[24]
- Portugal INCoDE.2030-National Digital Competencies Initiative e.2030: Launched in 2016 this initiative will bring together public and private organisations to overcome: generalize digital literacy, stimulate employability and professional training and specialisation in digital technologies and applications, and to ensure strong participate on in international R&D networks and the production of new knowledge in digital areas.[25]

[22] Contribution from the Government of Uganda.
[23] Contribution from the Government of Kenya.
[24] Contribution from the Government of Bulgaria.
[25] Contribution from the Government of Portugal.

- Canada's Innovation and Skills Plan: Introduced in 2017, this is an ambitious effort to make Canada a world-leading centre for innovation, to help create more well-paying jobs, and help strengthen and grow the middle class. It includes equipping Canadians with the tools, skills and experience they need to succeed in the workforce, now and into the future.[26]
- United Kingdom's Digital Inclusion and Skills Policy: Established in 2017, it aims at ensuring digital inclusion and ensuring that everyone who is capable of participating in the digital economy does so.[27]
- South Africa's revised National Broadband Policy and Broadband Strategy: Created in 2010 and revised in 2013, the Broadband Policy aims at ensuring universal access to reliable, affordable and secure broadband infrastructure and services by 2020 and stimulates sustainable uptake and usage of ICTs.[28]

4.3 Establishment of initiatives that promote entrepreneurship in the digital economy

Countries should also implement special policies and partnerships to support people, particularly, youth and women, to participate in the digital economy. These include among others: 1) school programs that incorporate ICT and entrepreneurship skills in high school and vocational education curriculum; 2) government programs that support un-employed youth and women to enable them to join the workforce that requires digital skills and to start businesses that embrace the opportunities that brought by e-business. 3) policies that support community programs and activities of NGOs that aims to build up digital skills and bridge the digital divide in the wide society; 4) targeted programs for women and youth in terms of financial support, training program, online platform, community activities, and tax incentives to companies who prioritize youth and women employment and digital skill training; 5) initiatives that encourage entrepreneurship in digital economy sectors such as e-business, automation or digitisation of existing business, or business or activities that contribute to digital competencies; 6) Set up institutions such as incubators to support digital start-up companies.

4.4 International collaboration to facilitate technology adoption and knowledge exchange

Like many other areas of international development, enhancing digital skills requires international collaboration between countries that possess infrastructure, human resources, and knowledge, to work together with countries lacking these resources to equip their future workforce with necessary digital skills. International collaborations already exist in the development of infrastructure such as telecommunication networks and building ICT centres.

[26] Contribution from the Government of Canada.
[27] Contribution from the Government of United Kingdom.
[28] Contribution from the Government of South Africa.

For example, an Information Access Centre has been built in Uganda[29] with the assistance of the government of Korea, which will facilitate e-government initiatives.

Nevertheless, the improvement of digital competencies needs extensive investment in training staff, designing curricula, and providing information centres, all of which require a more in-depth international collaboration. There are several areas in which international collaboration can contribute to the strengthening of digital competencies in countries:

a. Training of researchers and educators. Due to the lack of knowledge and experience in ICTs, teachers and trainers in developing countries are often unfamiliar with advanced technologies or complex technical skills. Having gained sufficient experience with working in the technology industry, professional researchers and ICT trainers can share their knowledge about digital skills' training with teachers in developing countries, and exchange new ideas or frameworks of curriculum designs. In 2016, Germany, in collaboration with SAP, the Cape Town Science Centre, and the Galway Education Centre, provided coding courses for teachers and students in Rwanda[30].

b. Collaborative development of digital skills' programmes. Students, teachers, and governments, particularly in developing countries and LDCs, might be passive users of emerging technologies, who seldom re-design or adaptation to meet local needs. This lack of creative use of technologies is partly due to the lack of updated digital training on new technologies. Multinational technology companies could play an extremely important role in providing sessions for educators in developing countries on how to localise the new technologies in the local context, and how to improve students' advanced digital skills such as coding.

c. Collaborative development of international digital competencies' education platforms. A good example of such an international online forum is Code Club, supported by Raspberry Pi Foundation, a charity based in the UK. By working with institutions in over 100 countries, Code Club provides training materials for educators and volunteers around the world to teach children to code (Code Club, 2017). Simply by translating training programs into local languages, courses on Code Club could be used in ICT classrooms in multiple countries, benefiting children around the world. Countries could also work together in higher education and research into ICTs and could produce more holistic scientific knowledge on digital technology and the digital economy. An international collaborative research project, the India-UK Advanced Technology Centre (IU-ATC), will benefit users in India and the UK through rigorous research on the access, adoption, use, and creation of ICTs (EPSRC, 2012). International collaborations on digital competencies will enable a global solution to disruptive

[29] Contribution from the Government of Uganda.
[30] Contribution from the Government of Germany.

technologies, and will benefit both developing countries and developed countries in the long run.

4.5 Public-private partnerships in delivering digital skills and building digital infrastructures

Public-private-partnership (PPP) can support training provision, infrastructure development, and data facility building. Technology companies are already playing important roles in some developed countries to support the training and teaching of digital skills. There is also a tendency that the public and private sectors become involved in the delivery of digital skills' training and education. For example, Microsoft works with the British government to train civil servants how to use new technologies such as cloud services (Microsoft, 2017). The P-TECH model mentioned above also exemplifies public-private partnerships in institutional education: while national and local government point out the direction of ICT for education and regulate education policies that encourage the teaching of digital skills, private sectors like technology companies introduce knowledge and teaching resources related to new technologies into the traditional classroom. Companies also bring the most up-to-date insights into the most necessary skills in the industry and incorporate training of increasingly needed skills into the teaching programmes. The partnership also appropriately connects digital education with digital employment by guiding well-trained and newly graduated young people into the most promising industries and fields. Finally, schools are bridging the gap between public and private sectors by setting up policies and regulations regarding the administration of students and recruitment of teachers or trainers. Schools also provide facilities, spaces, and hardware in digital training, and help organise standardised performance assessments to give feedback to both students and teachers (P-TECH, 2017). Unlike traditional literacy and numeracy skills, digital skills are highly related to new technologies used in various industries, are evolving at a rapid speed, and require experts and professional technical staff to assist the teaching of digital competencies. Therefore, training programmes in digital competencies require strong public-private partnerships in many aspects.

On the one hand, the collaboration between public and private sectors in digital skills training needs to be based on the provision of technology equipment and software. Traditional teaching tools such as whiteboards might help in the training of soft skills such as critical thinking, but would be inefficient in the teaching of coding or data analysis skills. Since technology companies have advantages in software engineering and interface designing, they could provide equipment and software specifically designed for educational purposes. For example, developers of Swift, an educational application on iPad, design an interactive and playful interface for children to learn to code (Apple, 2017). On the other hand, education policies promoted by national and local government also help the private sector to recruit highly-skilled workers and technology experts. Close partnership between government and companies leads to more frequent information and knowledge exchange on digital competencies and thus could narrow the employment gap between the education system and the job market, designing more

practical and career-oriented curricula for the students. Students also benefit from the close public-benefit relationship by getting the highest quality training on digital skills, and are offered chances to harness their skills through internships or on-the-job training. Partnerships between universities and governments could also introduce cutting-edge technological skills to learners. For example, Portugal established a partnership with several universities, including MIT, Carnegie Mellon University, and Indian Institutes of Technology, to establish networks that support the enhancement of digital competencies[31].

4.6 International cooperation for capacity-building and research

International organisations will play an important role in facilitating public-private conversations, connections, and collaborations on digital competencies. To date, several organisations have highlighted the importance of digital skills in future employment and have offered policy guidelines for policymakers around the world. Efforts are also made to encourage collaborations between governments and technology companies. For example, by initiating the 4th Thursday in April every year as International Girls in ICT Day, ITU has facilitated an international environment for public and private sectors to be involved in the global goals of enhancing digital skills for all (UN Women, 2017). By having worked with companies such as Coursera the World Bank has also partnered with the private sector to deliver ICT training in developing countries through its New Economy Skills for Africa Programme (NESAPICT) programme. This programme aims at teaching ICT skills to students in African countries. The purpose of the programme is to keep up with the digital market, bringing MOOC education into developing countries and designing online courses that meet the needs of the future workforce (ITU, 2012; World Bank, 2013b).

Box 10: EQUALS – the global partnership for gender equality in a digital age

Sex-disaggregated data on digital competencies and gender statistics are of utmost importance for evidence-based policy making. The science, technology and innovation community can contribute to develop targets, indicators and benchmarks to track the progress of women's and girls' access to and use of ICT as well as their digital competencies.

The science, technology and innovation community further needs to focus on existing efforts by a range of different stakeholders. EQUALS – the global partnership for gender equality in a digital age – is an important multi-stakeholder approach that should be strengthened in order to harmonise skills programmes for women and girls that help to tackle the gender digital divide.[32]

Under the EQUALS' Leadership coalition, the International Telecommunications Union (ITU), UN Women and the International Trade Centre (ITC) and the United Nations Conference on Trade and Development (UNCTAD) aim to operationalize the initial

[31] Contribution from the Government of Portugal.
[32] Contribution from the Government of Germany.

priorities identified in a clear work plan for 2017-2018. In this respect there were established five main priorities that are closely related to the women's engagement and leadership in ICTs/Tech industry. These priorities focus on *digital entrepreneurship, recruitment, retention, promotion and content.* Building upon already existing initiative such as the Women Empowerment Principles (WEPs)[33], the SheTrades[34] platform and the Project Include[35], the coalition aims to identify good practices in leading ICT and Tech companies. Later these good examples will contribute to the formulation of specific guidelines encouraging the leadership of women in the industry.

International cooperation can also contribute to improve infrastructure, accelerate the development of digital skills, building data collection, and storage and analysis capabilities. International cooperation can also play an important role in developing regulations and ethics in data collection, usage and open access. In addition, multilateral and multistakeholder initiatives, such as the UN Commission on Science and Technology for Development (CSTD), can contribute to explore technological advances and the policy changes they create for countries in terms of capacity building; to provide a forum for the exchanging of good practices and lessons learned in promoting digital competencies; and to facilitate and promote formal collaboration between countries and stakeholders groups.

4.7 Summary

Existing and emerging digital technologies are changing the structure of the global economy and are revolutionising the everyday lives of individuals. The rapid growth of the ICT sector and the digitalisation of traditional industries have led to an increasing demand for employees who have digital competencies to use, adopt, develop and create digital technologies. Students need to receive basic digital competencies' training before entering the job market, and workers need to acquire specialised digital skills through on-the-job training programmes to adapt to the digitalisation and computerisation processes. Women and the youth have also encountered new challenges as well as working opportunities in the digital age, and thus special training programmes need to be created and provided to equip them with sufficient digital skills.

In response to this changing scenario, this Chapter has identified a number of policy and strategy considerations that could potentially assist countries in their efforts to build digital competencies as part of science, technology and innovation-led strategies for sustainable development. These include, but are not limited to:

1. Identify key skills needed to build up digital competencies through, among others, international collaboration, and incorporate them as a part of the *compulsory* formal

[33] Women Empowerment Principles (WEPs) - http://weprinciples.org
[34] SheTrades platform- https://shetrades.com/
[35] Project Include- http://projectinclude.org/

curriculum in primary or secondary education, which can be decided and implemented by government of individual member states according to the situation of each country. This also means a change of education regulation that makes basic ICT skills compulsory.

2. Support firms, community school and civil society organisations to provide training of broad skills to existing workforce and the population. This should include broad skills for digital competencies including basic ICT skills for the workplace and in the wider social life, life-long learning capabilities and entrepreneurship skills.

3. Special policies and partnerships to support youth and women in this transition in both the private and public sectors. These include 1) targeted programs for women and youth in terms of financial support, training program, online platform, community activities, and tax incentives to companies who prioritize youth and women employment and digital skill training; and youth and women digital entrepreneurship promotion; 2) incorporating ICT and entrepreneurship skills in high school and vocational education curriculum; 3) policies that support community and non-governmental organisations (NGOs) programs that aim to bridge the digital divide in the society, and with special focus on youth and women.

4. Investment in data resource capabilities, including facilities for data collection, storage, and transmission, and capabilities for big data analysis and capabilities integrating results for policy making and business decision making. This include building national big data centres, rolling out full broadband coverage in developing countries, and regional high-speed computing and processing facilities for big data analysis.

5. Special policy and financial support to encourage entrepreneurship in digital economy sectors such as e-business, automation or digitisation of existing business, or commercial activities that contribute to building digital competencies.

6. Better use of digital methods such as online platforms for international knowledge sharing and capabilities building.

7. Build up public-private-partnership (PPP) in support of training provision, infrastructure development, and data facility building.

8. Reform tax, finance, industry and labour market policies to develop an incentive structure that encourages and facilitates investment and labour participation in the digital economy, for example, tax breaks, low interest rate bank loans, digital SME support funds, and preferential human resource or migration policies for digital talents.

9. Set up institutions such as incubators to support digital start-up companies.

10. Strengthen international cooperation to improve the infrastructure, accelerate the development of digital skills, building data collection, storage and analysis capabilities. International cooperation can also play an important role in developing regulations and ethics in data collection, usage and open access, and in providing a forum for the exchange of good practices and lessons learned.

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