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BUILDING DIGITAL COMPETENCIES TO BENEFIT FROM FRONTIER TECHNOLOGIES

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This series of publications seeks to contribute to exploring current issues in science, technology and innovation, with particular emphasis on their impact on developing countries.

The term "country" as used in this study also refers, as appropriate, to territories or areas. In addition, the designations of country groups are intended solely for statistical or analytical convenience and do not necessarily express a judgment about the stage of development reached by a particular country or area.

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ACRONYMS

BHER	Borderless Higher Education for Refugees
ICT	information and telecommunications technology
ILO	International Labour Organization
IPA	Institute of Public Administration of Bulgaria
ITC	International Trade Centre
ITU	International Telecommunication Union
LDCs	least developed countries
MOOC	massive open online course
NESAPICT	New Economy Skills for Africa Programme
OECD	Organization for Economic Cooperation and Development
SciELO	Scientific Electronic Library Online
STEM	science, technology, engineering and mathematics
UNCTAD	United Nations Conference on Trade and Development
UNHCR	United Nations High Commissioner for Refugees
WEF	World Economic Forum
WEPs	Women Empowerment Principles

TABLE OF CONTENTS

LIST OF BOXES

LIST OF TABLES

1. INTRODUCTION: TECHNOLOGICAL CHANGE AND ITS IMPACT

Technological changes observed in recent years, particularly driven by the rapid development of information and communications technologies (ICTs), offer the potential to transform economies and improve the living standards of many people. Furthermore, they have a strong potential to disrupt productive sectors and markets, including through technological convergence and recombination.

Recent advances in ICTs, characterized by a reliance on digital data storage and analytics, fast-growing capabilities at a declining cost and increasing ease of use, have led to an increasing democratization of technologies. Examples of these technologies include the Internet of things, big data, three-dimensional printing, artificial intelligence, robotics, automation, biotechnology, nano- and microsatellites, neurotechnology, synthetic biology, nanomaterials, advance energy storage technologies and blockchain.[1] The applications of these technologies offer new opportunities for economic prosperity, social inclusion and environmental sustainability. Furthermore, the cross-cutting application of many emerging technologies, especially those digitally enabled, can also contribute to sustainable development.[2] Examples of these applications include sensor devices for improving agricultural productivity, microinsurance for farmers distributed through mobile devices, mapping data for the control of epidemic outbreaks and smart water-management systems.[3]

The implications of current technological advances for labour markets and jobs have been the subject of much debate, which has largely focused on the impact of digital platforms and automation. While digital platforms are creating new types of occupations and generating entrepreneurial opportunities – especially for women – they can also create greater pressure on pay and working conditions, owing to work fragmentation and the provision of remote services.[4] As regards automation, the increased automation of tasks can release workers from dangerous, predictable and routine tasks so they can pursue safer, more creative and interesting work tasks, as well as leisure activities. However, it can also reduce the need for workers and potentially even whole industries, since it raises productivity and can increase the scale of operations at marginal cost.[5] The net impact of new technologies and their consequences on labour markets and jobs remains uncertain, including on the type of jobs and sectors that will remain or will be created.

Technological change can affect women and men differently.[6] ICT services provide relatively well-remunerated employment for women, but the share of women in ICT specialist occupations remains very low, especially in developing countries.[7] A recent survey among 13 major developed and emerging economies revealed that female employment is concentrated in low-growth or declining occupations, such as sales, business and clerical work. Women are also less represented in sectors in which automation is expected to displace jobs such as manufacturing and construction. Further, there are few women in the science, technology, engineering and mathematics (STEM) job families and may therefore not be able to take advantage of the increased demand for workers with skills in these areas.[8]

Taken together, rapid technological change offers potentially transforming development opportunities for countries but also creates significant concerns that policymakers need to address to ensure technologies are leveraged for sustainable and inclusive development. Development gains offered by new and emerging technologies are not

[1] Organization for Economic Cooperation and Development (OECD), 2016, *OECD Science, Technology and Innovation Outlook 2016 (OECD Publishing, Paris); E/CN.16/2016/3.*

[2] A/72/257.

[3] E/CN.16/2016/3.

[4] J Drahokoupil and B Fabo, 2016, The platform economy and the disruption of the employment relationship, European Trade Union Institute Policy Brief No. 5.

[5] E/CN.16/2016/3.

[6] OECD, 2017, Going digital: The future of work for women, Policy Brief on The Future of Work.

[7] UNCTAD, 2017, *Information Economy Report 2017: Digitalization, Trade and Development* (United Nations publication, Sales No. E.17.II.D.8, New York and Geneva).

[8] E/CN.16/2016/3.

automatic. While new technologies create new jobs and development opportunities, they also increase the demand for digital skills and competencies.[9] This underlines the importance of addressing the gaps that exist in terms of capabilities across and between countries, sectors and segments of the society, so that societies can adapt and benefit from technological changes.

Estimates indicate that 85–90 per cent of future jobs will require ICT skills by 2020.[10] More than a third of the labour force in OECD countries, however, is reported to have an extremely low capacity to use digital technologies productively, while 56 per cent of the population has no ICT skills.[11] Also, women are more likely than men to lack digital skills. The widening gap between the knowledge, skills and abilities of young people entering the workforce and the knowledge, skills and abilities that employers are seeking has been identified as an important deterrent to growth.[12] Moreover, developing countries are witnessing an increase of young people in the labour market. About half a billion young Chinese and Indian people will join the workforce in the coming decades. In Africa, it is expected that about 11 million young Africans will join the labour market every year for the next decade.[13] This stresses the need for policymakers and educators to adapt educational curricula to changing labour markets demands.

At the same time, the effects of ICTs are not limited to jobs but also to social and civic participation in societies. Having the necessary digital competencies enhances people's quality of life and the effectiveness of their work. Therefore, digital competencies and skills are essential to ensure effective participation in the current and future world as well as to benefit from existing and emerging technologies.

This study explores ways in which digital skills can be developed and harnessed to support sustainable development. The remainder of the report is structured as follows:

Chapter II discusses the types of skills that countries need to prepare the future workforces for the changing world and to maximize the development opportunities offered by existing and emerging technologies.

Chapter III examines the potential of existing and emerging digital technologies in building and enhancing digital skills, particularly in developing countries. The chapter discusses the promise of technologies for education, specifically, massive open online courses (MOOCs), remote learning, and opportunities of open access.

Chapter IV focuses on the environment to enable skills development. It addresses aspects of shaping education in school, on-the-job and throughout life, and the importance of developing an enabling environment to support skills development.

Chapter V presents key findings and policy considerations that can help countries to develop digital competencies.

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9 Further, inequality in the skills that allow people to use technologies is one factor that could potentially exacerbate the digital divide. In addition to access to the Internet, ICT user sophistication and digital skills for Internet use have also been identified as determinants of the digital divide. See E Hargittai, 2003, How wide a Web? Inequalities in accessing information online; E Hargittai and A Hinnant, 2008, Digital inequality differences in young adults' use of the Internet, *Communication Research*, 35(5):602–621.

10 See https://ec.europa.eu/jrc/en/news/job-market-fails-unleash-ict-potential-9692 (accessed 27 February 2018).

11 Broadband Commission for Sustainable Development, 2017, Working Group on Education: Digital Skills for Life and Work.

12 The Economist Corporate Network, 2016, *Shaping the Future of Work: Technology's Role in Employment (Dubai).*

13 See https://openknowledge.worldbank.org/bitstream/handle/10986/25010/Will0the0digit00realizing0job0gains.pdf?sequence=1&isAllowed=y (accessed 28 February 2018).

2. DIGITAL SKILLS AND COMPETENCIES FOR THE TWENTY-FIRST CENTURY

In general, digital competence encompasses the knowledge and skills required for an individual to be able to use ICT to accomplish goals in his or her personal or professional life. Digital competencies should be perceived as not only concerned with technical skills, but more focused on cognitive and social and emotional aspects of working and living in a digital environment.[14] The notion is a complex one, and beyond digital literacy, implies the ability to understand media, to search for information and be critical about what is retrieved, and to be able to communicate with others using a variety of digital tools and applications. Digital competence is a multifaceted moving target, which is constantly evolving as new technologies appear.[15]

Different types of digital competencies are needed to adapt to the changing technological landscape. Six major drivers are among those relevant for the work skills and digital competences of the future: increasing globalization, extreme longevity, workplace automation, fast diffusion of sensors and data processing power, ICT-enabled communication tools and media, and the unprecedented reorganization of work driven by new technologies and social media, which are massively increasing collaboration opportunities.[16] Several organizations and initiatives have carried through efforts to identify and categorize the digital skills and competencies needed for the future. Despite their different backgrounds, these organizations call for changes to current curricula and, to a certain extent, in educational attitudes. Namely, all encourage a move from learning for specific jobs towards acquiring skills which allow people to adapt to the changing tasks arising from technological change.[17] Table 1 presents examples of selected categorizations of such skills and competencies.

[14] Y Eshet-Alkalai, 2004, Digital literacy: A conceptual framework for survival skills in the digital era, Journal of Educational Multimedia and Hypermedia, 13(1):93–106.

[15] A Ferrari, 2013, DIGCOMP: a Framework for Developing and Understanding Digital Competence in Europe (European Union, Luxembourg).

[16] Institute for the Future, 2011, Future Work Skills 2020.

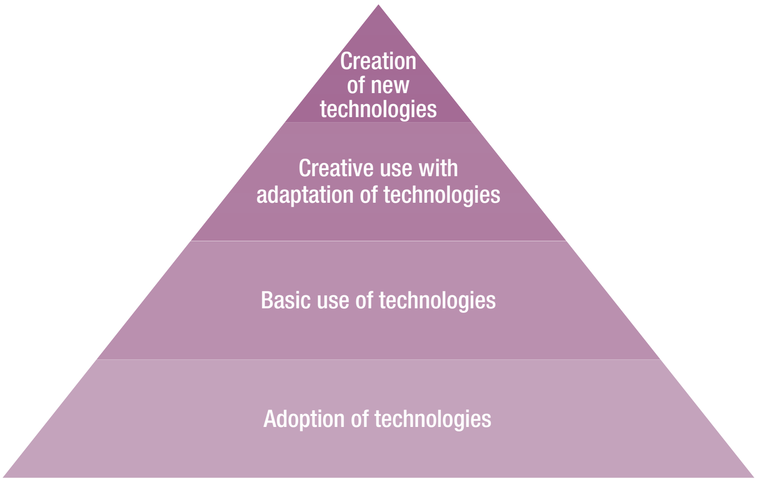
[17] World Economic Forum, 2016, "The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution."

Table 1 Different categorizations of digital skills

Organization	Skills
Job-ready digital skills for decent jobs (International Labour Organization (ILO) and International Telecommunication Union (ITU))	Basic digital skills (related to the use of technologies) Advanced digital skills (coding and other algorithmic knowledge) Soft skills (such as communication and leadership) Digital entrepreneurship (online market research and using financial platforms)
Work-related skills (World Economic Forum)	Abilities (cognitive and physical) Basic skills (content and processing skills) Cross-functional skills (social systems, complex problem solving, resource management and technical skills)
Future of work (OECD)	Technical and professional skills (specific and often industry-specific skills such as installation and operation of robots) Generic ICT skills (skills needed to understand, use and adopt technologies; life-learning ability to adapt to technology changes) Complementary ICT soft skills (creativity, communication skills, critical and logical thinking, teamwork, digital entrepreneurship)
Digital Skills Toolkit (ITU)	Digital skills: basic, intermediate, advanced twenty-first century skills (foundational skills, competencies, character qualities) Emerging and specialized skills (computational thinking and coding, data literacy, mobile literacy)

Source: ITU, 2018, Digital Skills Toolkit; ITU, 2018, ILO-ITU Digital Skills for Decent Jobs for Youth Campaign to train 5 million youth with job-ready digital skills; OECD, 2016, Skills for a digital world, Policy Brief on the Future of Work; World Economic Forum, 2016, *The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution* (Geneva).

Box 1 Pyramid of digital skills



Four different levels of digital skills are needed during the process of adoption, use and domestication of technologies: those required to adopt technologies, those needed in the basic use of technologies, those necessary for the creative use and adaptation of technologies, and those essential for the creation of new technologies (see box 1). These categories can be further grouped into two categories: skill sets for all and skill sets for ICT professionals (see table 2).

The most fundamental skill sets in the digital era are capabilities to adopt new technologies. In this context, "digital literacy for all" is a basic requirement to enable every citizen to participate fully in the digital society.[18] This involves basic education and literacy, as well as familiarity with technological devices.[19] Basic use of technologies requires digital skills that enable direct use of technologies, which include a basic understanding of emerging technologies and technology applications and knowledge about digital privacy and security. Box 2 presents the "I click sensibly" education campaign under implementation in Poland. This campaign aims at creating cybersecurity awareness in primary school children.[20] This type of knowledge enables users to actively extract the information they need from the Internet, instead of passively being receivers and targets of online advertisements.[21] This basic knowledge of ICTs allows users to solve everyday

[18] Broadband Commission for Sustainable Development, "Working Group on Education: Digital Skills for Life and Work."

[19] ITU, 2018, "Digital Skills Toolkit."

[20] Contribution from the Government of Poland, available at https://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con20_Poland_en.pdf (accessed 4 December 2018).

[21] W. Russell Neuman, *The Digital Difference: Media Technology and the Theory of Communication Effects* (Cambridge, MA: Harvard University Press, 2016).

Table 2 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 or generic use	Basic understanding of technologies, software and applications Knowledge of digital rights, privacy, security and permanence of data[a] Ability to make use of information and data, including basic issues of data storage, management and organization to construct calculations and answer questions[a] Ability to use digital technologies to collaborate, communicate and create[a]
Digital skills for ICT professionals	Creative use and adaptations	Basic computing skills Familiarity with basic algorithms
	Creation of new technologies	Sophisticated programming skills; knowledge of complex algorithms

[a] Broadband Commission for Sustainable Development, 2017.

Box 2 Cybersecurity awareness

Researchers estimate that, today, one in three Internet users is below 18 years of age. This share is likely to grow in the coming years as large parts of populations coming online are from countries with high shares of young people.[22] However, while children and teenagers might be better able to navigate the Internet than adults, it does not imply that they are digitally savvy and aware of the risks involved.[23]

The "I click sensibly" education campaign of Poland is one example of a response to the ever-growing scale of threats faced by young Internet users. The campaign aims at preparing primary school children to be active participants in the digital age. The training, delivered by the Office of Electronic Communications, includes:

- 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, etc.)
- How to creatively use new technologies.

This country-wide campaign reached 40,000 participants in 2017 and is expected to have trained 300,000 by 2021.[24] Furthermore, the campaign also targets adults, teachers, parents and guardians, through workshops to raise awareness about responsible Internet access by minors.[25]

problems and participate in community activities. Knowing how technology works can help users improve the efficiency of usage and optimize the outcome of technology usage. With increasing numbers of software and applications being used to accomplish everyday communicational and informational tasks, basic knowledge of ICTs is now essential for citizens to solve everyday problems, as well as to engage in community activities. Some non-ICT professionals may increasingly need to develop stronger skills to perform their duties. Some of these skills include proficiency in programming languages, data analysis and processing and modelling skills.[26]

Many of the advanced technologies are designed to be used in contexts where infrastructure, and natural and social resources differ from those in developing economies. To maximize the benefits of new technology, countries and companies need to have the digital skills to introduce modifications to new technologies.[27] Creating new technologies is the top of the skills' pyramid and are considered the skills that allow to contribute to the creation of more advanced technologies or the development of technology innovation. They include, for example, sophisticated programming skills, often including engineering aspects and use of complex algorithms such as machine learning.[28]

A. COMPLEMENTARY SKILLS

Digital skills are not enough to adapt to the changing demands of labour markets. There is an increasing call for strengthening uniquely human skills that cannot be easily replaced by machines and that provide the flexibility required for the current and future technological contexts. These competencies include complex problem solving, critical thinking, creativity and fine-tuned communication. When complemented with character qualities such as adaptability and grit, these competencies are an essential package to create the flexibility required for the current and future demands for the workforce.[29,30]

Research shows that occupations such as engineering and science are less susceptible to digitalization and computerization because these professions involve a higher degree of creativity and innovation compared with others.[31] Occupations that involve sophisticated communication skills are also less likely to become redundant in the digital era: natural language processing algorithms can detect emotions underlying text but are often inaccurate in grasping 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. Table 3 presents a non-exhaustive list of complementary skills.

[22] Sonia Livingstone, John Carr, and Jasmina Byrne, "One in Three: Internet Governance and Children's Rights" (Centre for International Governance Innovation and the Royal Institute of International Affairs, 2015).

[23] European Commission, "Keeping Children Safe in a World of Online Opportunity," *European Commission* (blog), February 6, 2018, https://ec.europa.eu/commission/commissioners/2014-2019/ansip/blog/keeping-children-safe-world-online-opportunity_en.

[24] Info retrieved from http://en.archiwum.uke.gov.pl/uke-participated-in-the-establishment-of-the-guinness-record-in-programming-23321

[25] Contribution from the Government of Poland.

[26] Broadband Commission for Sustainable Development, 2017.

[27] Z Huang and P Palvia, 2001, ERP implementation issues in advanced and developing countries, *Business Process Management Journal, 7(3):276–284.*

[28] Ibid.

[29] ITU, 2018, "Digital Skills Toolkit."

[30] Hasan Bakhshi et al., "The Future of Skills – Employment in 2030" (London: Pearson and Nesta, 2017).

[31] Carl Benedikt Frey and Michael A. Osborne, "The Future of Employment: How Susceptible Are Jobs to Computerisation?," *Technological Forecasting and Social Change* 114 (2017): 254–80, https://doi.org/10.1016/j.techfore.2016.08.019.

Table 3 Complementary soft skills for the future workforce

Type of soft skills	Description
Sense making	Ability to determine the deeper meaning or significance of what is being expressed
Social intelligence	Ability to connect with others deeply and directly, to sense and stimulate reactions and desired interactions
Computational thinking	Ability to translate vast amounts of data into abstract concepts and to understand data-based reasoning
Novel and adaptive thinking	Proficiency in thinking and coming up with solutions and responses beyond that which is rote or rule-based
Cross-cultural competency	Ability to operate in different cultural settings
New media literacy	Ability to critically assess and develop content that uses new media forms and to leverage these media for persuasive communication
Transdisciplinary	Ability to understand concepts across multiple disciplines
Design mindset	Ability to represent and develop tasks and work processes for desired outcomes
Cognitive load management	Ability to filter information for importance and to understand how to maximize cognitive functioning using a variety of tools and techniques
Virtual collaboration	Ability to work productively, drive engagement and demonstrate presence as a member of a virtual team

Source: Institute for the Future, 2011.

With the increase of the platform economy, soft skills for digital entrepreneurship are important for individuals to benefit from the digital economy.[32] Many countries acknowledge the importance of providing e-business training. Turkey aims to increase the share of individuals with entrepreneurship training from 6.3 per cent in 2012 to 15 per cent in 2018.[33] Bulgaria is fostering entrepreneurial culture among the young to reduce social exclusion and unemployment: The Entrepregirl project specifically targets the business skills of young women under 25 years of age.[34] In South Africa, the Council for Scientific and Industrial Research started an agri-entrepreneurship programme in the Eastern Cape. This project teaches high-school students farming as a business to empower the rural population.[35] At the global level, Technovation, a non-profit initiative, offers a mentoring programme and competition that teaches girls how to become technology entrepreneurs. Teams work together to develop a business plan and a mobile app aimed at benefiting their local communities.[36] Box 3 presents initiatives in different countries that aim to remedy the digital gender gap.

Box 3 ICT and the gender divide

ICT can be a tool for female empowerment by, for instance, providing better information and access to training. However, compared to men, women are less likely to acquire digital skills and remain underrepresented in ICT professions. Also, women worldwide are 12 per cent less likely than men to use the Internet. In LDCs, the gap amounts to 33 per cent, which is up from 30 per cent in 2013.[37] The examples below describe a wide range of efforts aimed at addressing these inequalities:

- In Turkey, the Women's Informatics Movement aims at empowering women through ICT education to ease their entry to the labour market, help them gain economic independence and strengthen their social position. From 2011 to 2012, 230 women aged between 16 and 30 years old received training. Furthermore, the Information Society Strategy and Action Plan (2015–2018) of Turkey intends to increase the diffusion of ICTs in society with a special focus on women. The Action Plan expects to raise women's Internet use from 38.8 per cent in 2014 to 65 per cent by 2018.[38]

[32] Contribution from the United Nations Major Group for Children and Youth. In addition to training, other factors also influence entrepreneurship initiatives, particularly for youth. These include risk management, high overhead costs and difficulty in gaining financial and legal legitimacy.

[33] Contribution from the Government of Turkey, available at http://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con23_Turkey_en.pdf (accessed 27 February 2018).

[34] Contribution from the Government of Bulgaria, available at http://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con15_Bulgaria_en.pdf (accessed 12 June 2018).

[35] Contribution from the Government of South Africa, available at http://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con22_SouthAfrica_en.pdf (accessed 12 June 2018).

[36] Technovation, "About Technovation," accessed 26 June 2018, https://technovationchallenge.org/about/.

[37] ITU, "ICT Facts and Figures 2017" (International Telecommunication Union, July 2017), http://www.itu.int:80/en/ITU-D/Statistics/Pages/facts/default.aspx.

[38] Contribution from the Government of Turkey.

- In 2016, Women of Uganda Network, in partnership with WomensNet and the Association for Progressive Communications, and with funding from UN-Women, implemented a joint project promoting women's participation in ICT policy in Uganda and South Africa. The project aims to increase women's decision-making and influence in Internet governance and ICT policies to promote women's rights across Uganda and the wider Africa. The project has provided training on gender and Internet governance to more than 35 women through enabling their participation in conferences and forums and delivering workshops on women's right and technology.[39]
- The Bulgarian Centre for Women in Technology project, Entrepregirl, focuses on enhancing entrepreneurship skills among women aged between 16 and 25 years old. It provides young female entrepreneurs with the opportunity to benefit from curated workshops, active mentorship and to participate in organized travels and sharing of experience with other influential women in the business sector. Established in 2014, the project has conducted four consecutive editions with more than 200 participants.[40]
- Ada, the National College for Digital Skills of the United Kingdom, is a specialist college which gives students, especially women and people from low-income backgrounds, the necessary digital skills to build their potential and help them begin a successful career in technology. Founded in 2016, it aims at training up to 5,000 students by 2020 by delivering a higher technical level of digital skills across a diverse range of sectors, including banking, gaming and business.[41]

B. DIGITAL COMPETENCIES FOR DIFFERENT ECONOMIC SECTORS

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. However, the needs for digital competencies vary according to the sectors of the economy and the level of development of countries. Nevertheless, digital competencies are becoming important in all sectors of the economy from agriculture to industry and services due to the increasing ubiquity of ICTs and growing capabilities of new technologies. Box 4 shows the potential contribution of recent technological advances to the agriculture sector.

Box 4 ICT and agricultural development

Needs for digital competencies also vary according to different countries' economic structures. Where relatively small-scale agriculture is dominant, basic digital literacy of new technologies such as mobile phones is essential to improve access to information on, for instance, weather, markets and financial services. Empirical research in rural India shows that mobile phones can be useful information tools to connect remote farmers with agricultural experts via video messages. The ability to use these mobile agricultural services can improve farmers' agricultural knowledge, which in turn could translate to better output and thus income.[42]

While education on basic ICT use facilitates rural development, ICT professionals who can modify technologies are equally important in this context. For example, the mobile technology used in rural India is created around local issues and knowledge. The creation process requires talents to adapt content and to incorporate sensibilities to the local context.[43, 44]

Similarly, South Africa has been researching how to improve digital literacy in rural areas. ICT gives women in remote rural areas the possibility to obtain agricultural information. Funded by the Department of Science and Technology and the Department of Rural Development and Land Reform, the concept of the Digital Doorway is to provide women with digital assistance and thus make information available that allows women to improve farming decisions to advance their livelihoods.[45]

In countries where technology development remains in its early stages, it is important to strengthen basic technical skills and generic skills. Once users and companies in the country have adopted and domesticated the technology, more sophisticated professional skills and ICT complementary "soft skills" become important for the innovation of domesticated technologies in the country. Throughout the adoption and integration process of technology, policy interventions should be both selective and geared towards maximizing the outcomes of economic development.[46]

39 See http://wougnet.org/home/project/women-s-participation-in-ict-policy.

40 Contribution from the Government of Bulgaria.

41 Contribution from the Government of the United Kingdom, available at https://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con25_UK_en.pdf (accessed 9 April 2019).

42 Xiaolan Fu and Shaheen Akter, "The Impact of Mobile Phone Technology on Agricultural Extension Services Delivery: Evidence from India," *The Journal of Development Studies* 52, no. 11 (2016): 1561–76, https://doi.org/10.1080/00220388.2016.1146700.

43 Ibid.

44 Michelle J. Eady, "Eleven Design-Based Principles to Facilitate the Adoption of Internet Technologies in Indigenous Communities," *International Journal of Social Media and Interactive Learning Environments* 3, no. 4 (2015): 267–89, https://doi.org/10.1504/IJSMILE.2015.074010.

45 Contribution from the Government of South Africa.

46 Sanjaya Lall, "Technological Capabilities and Industrialization," *World Development* 20, no. 2 (1992): 165–86, https://doi.org/10.1016/0305-750X(92)90097-F.a.

Countries in which the manufacturing sector dominates the economic growth will require a workforce with specialized skills in industrial robotics, automation and the Internet of Things. As automation becomes more sophisticated, there is an increasing need for workers to minimize the risk of being displaced by machines. On-the-job training activities can help to reduce this risk. To date, this displacement remains, however, a phenomenon limited to a few countries with skill-intensive manufacturing, particularly in electronics and automobiles.[47,48] Nevertheless, a workforce able to use new technologies is important to incorporate digital technologies into manufacturing and avoid bottlenecks.[49] Additionally, new technologies can make small-scale manufacturing profitable, for instance by combining 3D printing and robotics. This small-scale manufacturing could be sufficiently flexible to grow production along with growing demand, on the condition that employees can use and adapt technology appropriately.[50]

Historically, industrialized countries have evolved from being industry-centred to becoming more service-based economies.[51] Today the service sectors are growing globally. Service industries, such as tourism, financial and health care services, require sophisticated and specialized digital competencies. For example, the increasing sophistication of artificial intelligence enables customer service workers to concentrate on more complex cases rather than on solving routine problems. Employees are becoming specialists and therefore need more advanced skills.

In the financial sector, technologies are transforming business models. Mobile banking, for instance, brings better financial inclusion to previously excluded groups. As the customer base is broadened, in the background, financial services remain highly specialized. For instance, employees need the technical understanding to perform big data analytics and adapt computational models to improve the efficiency of services. Meanwhile, new technologies such as blockchain are transforming the way financial infrastructures are designed and used.[52,53]

Furthermore, digital technologies grow e-commerce possibilities. Small businesses can increasingly participate in larger markets and without large upfront infrastructure cost. To harness this potential, an emerging e-commerce sector requires sophisticated digital skills to manage supply chains, programme websites and handle shipping.[54] Finally, many advanced technologies are designed to be used in contexts where infrastructure and natural and social resources differ from those in developing economies. Therefore, investment maybe required in local adaptation in order to benefit from these technologies.

[47] UNCTAD, "Trade and Development Report 2017: Beyond Austerity - Towards a Global New Deal" (Geneva: UNCTAD, 2017), http://unctad.org/en/PublicationsLibrary/tdr2017_en.pdf.

[48] UNCTAD, "Robots and Industrialization in Developing Countries," Policy Brief (Geneva: UNCTAD, 2016), http://unctad.org/en/PublicationsLibrary/presspb2016d6_en.pdf.

[49] National Academies of Sciences, Engineering, and Medicine, *Information Technology and the US Workforce: Where Are We and Where Do We Go from Here?* (Washington, DC.: National Academies Press, 2017).

[50] UNCTAD, "Trade and Development Report 2017: Beyond Austerity - Towards a Global New Deal."

[51] UNCTAD, "Robots and Industrialization in Developing Countries."

[52] Bernard Marr, "A Complete Beginner's Guide to Blockchain," Forbes, January 2017, https://www.forbes.com/sites/bernardmarr/2017/01/24/a-complete-beginners-guide-to-blockchain/.

[53] PwC, "Financial Services Technology 2020 and Beyond: Embracing Disruption," 2016.

[54] UNCTAD, "Information Economy Report: Digitalization, Trade and Development."

3. EXISTING AND EMERGING TECHNOLOGIES FOR EDUCATION

Traditional teaching curricula and training programmes can contribute to the enhancement of digital skills. In addition, new technologies can also help build digital competencies and knowledge. In particular, digital technologies enable interactions between educators and students, provide multimedia interfaces that facilitate learning and increase flexibility in the delivery of training. At the same time, digital technologies could provide education access to those who might not be able to benefit from formal education. Recent literature has identified massive open online courses, open access to scientific literature and educational resources, and technology-mediated teaching and learning as some of the existing and emerging technologies that can contribute to building digital skills and competencies (see box 5 for country examples on e-learning).[55]

Box 5 E-learning

Distance learning has existed for a long time. With new and emerging technologies, e-learning and mobile learning are becoming more attractive, mainly because the cost of remote learning opportunities is declining rapidly while making learning more interactive. Several countries are deploying initiatives to improve their e-learning models.

For instance, one of the priorities of the strategy of Bulgaria for effective implementation of ICTs in education and science (2014–2020) is to transition to a fully cloud-based distance and mobile education system. The new mobile learning model will supposedly allow more flexibility and efficiency while also lowering existent social barriers and enhancing equality in learning opportunities. Ultimately, using this strategy, Bulgaria plans to establish a "ubiquitous learning" or "u-learning" system which would also allow more of the population to participate in lifelong learning.[56]

In Turkey, the Department of Science, Technology, and Innovation Policy (TÜBİTAK) launched the "TÜBİTAK 5002 – Academic e-Course Calls", a programme to support the development of high-quality online course material that is made available to students at all levels of education with the aim of improving equal opportunities in education.[57]

A. MASSIVE OPEN ONLINE COURSES

Massive open online courses (MOOCs) are online courses that allow for open access and participation through the Internet and that could contribute to e-learning. They offer various features in addition to online video lectures, including online social sharing and interactive learning methods, and community teaching assistants that moderate discussion forums, track the activities of students and assess their performance. Although courses are organised in similar ways to traditional offline teaching programmes, students do not need to register with schools or universities to learn, and they can take self-paced courses. Potentially, these courses could deliver mass education at low cost and thus help achieve Sustainable Development Goal 4 ("ensure inclusive and equitable quality education and promote lifelong learning opportunities for all"). Box 6 presents an example of how MOOCs can help in the delivery of education to refugees.

Box 6 Connected learning in refugee education

"Leave no one behind" is the overarching theme of the 2030 Agenda for Sustainable Development. Access to quality education, however, remains a challenge for vulnerable groups, especially for refugee populations. The difficulties of enrolling and keeping students in education increase with the level of education. Only 1 per cent of refugee students has access to accredited programmes, most of which are funded through scholarships.

The Office of the United Nations High Commissioner for Refugees is committed to enabling access to higher education for refugees and displaced youths. In 2016, it established the Connected Learning Consortium, which focuses particularly on addressing the needs of refugees and displaced communities. The initiative provides refugees with education opportunities using connected learning[58] programmes through partnerships with higher education institutions.[59]

[55] For instance, the Commission on Science and Technology for Development examined open access, virtual libraries and the potential of massive open online courses in education delivery during its fifteenth and nineteenth annual sessions. See www.unctad.org/cstd (accessed 27 February 2018).

[56] Contribution from the Government of Bulgaria.

[57] Contribution from the Government of Turkey.

[58] The Consortium defines connected learning as "the development and exchange of knowledge and ideas among students and faculty through use of information technology that enables learning not bound by geographical limitations in contexts of fragility." See http://www.connectedlearning4refugees.org/what-we-do/.

[59] See http://www.connectedlearning4refugees.org/what-we-do/.

One of the current programmes is the Borderless Higher Education for Refugees (BHER) programme in partnership with York University, the University of British Columbia, Moi University and Kenyatta University. The programme is in implementation in the world's largest refugee camp, in Dadaab, Kenya. It offers an accredited two-year teacher education diploma with the potential to pursue a bachelor's degree afterwards. Students in the Dadaab camp take the same courses as students from the Canadian and Kenyan universities that are part of the consortium. Additionally, the programme offers remedial tuition to students to bridge knowledge gaps due to disruptions in education, poverty or poor educational quality. In 2016, the BHER learning centre in Dadaab had 206 students, 78 per cent of whom were refugees. Additionally, the first cohort of students went on to pursue bachelor's degrees in both Canada and Kenya.[60]

There are a variety of factors that may reduce potential access and use of MOOCs. Primary issues are infrastructure access (courses require a reliable Internet connection, including upgraded software and hardware) and skills access. The latter implies, being able to navigate to the courses and access the learning materials. To date, the average MOOC participant has at least some university education. Only a minority of course participants has low levels of education, so the scope as a mass education tool in the immediate future might be limited. Regarding fields, data show that 19 per cent of the courses offered in 2017 belonged to technology fields – including courses in computer science, data science and programming. Technology-related courses were the most popular subject category, followed by business.[61] Courses are predominantly available in English with the assumption that learners have a high level of language proficiency. Also, courses may not consider relevant local content.[62] Existing studies observe course participants to be predominantly men, especially for students from developing countries.[63] This low female participation appears to be linked to the dominance of technology-focused courses.[64] Furthermore, non-completion rates for MOOCs are high. One reason for this is lack of time due to prior commitments, which might particularly affect women given domestic and societal responsibilities.[65] These issues underscore the importance of considering local needs in developing the courses to reduce the digital divide. MOOCs do not guarantee improved educational outcomes. Experimentation, monitoring and evaluation can provide evidence on their impact and assist in scaling up e-learning.[66]

B. OPEN ACCESS TO SCIENTIFIC LITERATURE AND EDUCATIONAL RESOURCES

The creation of new technologies requires the exchange of information and knowledge worldwide. For researchers to remain at the frontier of emerging knowledge, two aspects are important: access to new knowledge and participating in cutting-edge research.

Open access databases of scientific journals allow access to information on scientific knowledge without cost. However, despite growing open access, not all research output is widely accessible. Particularly, researchers, universities and Governments in low- and middle-income countries are often excluded from the newest research because their institutions cannot afford the high cost of journal subscriptions. There are different initiatives which aim to remedy this lack of access. Open access publishers, such as the Public Library of Science, distribute digital copies of research articles online and provide open access for users.[67] Also, traditional scientific publishers are increasingly making science accessible to developing countries.[68]

Many of the leading journals, however, remain behind expensive paywalls. Research4Life is an example of how public–private partnerships can help to reduce the knowledge gap between developed and developing countries. Its five programmes – Hinari, AGORA, OARE, ARDI and GOALI – cover research in health, agriculture, environment,

[60] Ibid.

[61] Class Central, "By the Numbers: MOOCs in 2017," Class Central's MOOC Report, 2018, https://www.class-central.com/report/mooc-stats-2017/.

[62] Barbara Moser-Mercer, "Massive Open Online Courses in Fragile Contexts," in *Proceedings of the European Massive Open Online Courses Stakeholders Summit 2014* (Lausanne, 2014).

[63] Gayle Christensen et al., "The MOOC Phenomenon: Who Takes Massive Open Online Courses and Why?," SSRN Scholarly Paper (Rochester, NY: Social Science Research Network, 2013), https://papers.ssrn.com/abstract=2350964.

[64] Philip Guo and Katharina Reinecke, "Demographic Differences in How Students Navigate Through MOOCs."

[65] Khe Foon Hew and Wing Sum Cheung, "Students' and Instructors' Use of Massive Open Online Courses (MOOCs): Motivations and Challenges," *Educational Research Review* 12 (2014): 45–58, https://doi.org/10.1016/j.edurev.2014.05.001.

[66] UNCTAD, "Foresight for Digital Development - Report of the Secretary-General (E/CN.16/2016/3)," 2016, http://unctad.org/meetings/en/SessionalDocuments/ecn162016d3_en.pdf.

[67] PLOS, "Why Open Access? | PLOS," accessed 30 April 2018, https://www.plos.org/open-access/.

[68] PNAS, "Developing Countries Initiatives | PNAS," accessed 30 April 2018, http://www.pnas.org/page/about/developing-countries.

development and innovation, and global justice, respectively. These programmes provide online access to up to 85,000 peer-reviewed journals and offer digital skills training to make efficient use of the online resources.[69] Also, the Scientific Electronic Library Online (SciELO) was created to make research outcomes from Latin America and South Africa more easily accessible by indexing research from currently over 1,200 journals and creating a common database that allows easier access to the research findings.[70] Furthermore, scientists are increasingly using archiving websites to share their research with a much wider audience. Several national Governments have now made open access publication mandatory for all publicly funded research.[71] For instance, the Department for International Development of the United Kingdom and the European Commission now require research results to be made openly accessible.[72]

Also, open access business models have been implemented by scientific journals to facilitate access to scientific knowledge. These models, however, could reduce the competitiveness of scientific journals from developing countries in comparison with publications from developed countries. Journals require authors to pay an "open access fee," which can be too high for researchers from developing countries or may not be covered by the grants funding the research. At the same time, waiving the fee by rich journals also has its drawbacks given that journals from developing countries, which rely on submission fees, cannot compete. In addition, research has suggested that some types of open access business models may drive a redistribution of research resources. For instance, when authors from developing countries pay publishing fees, they end up cross-subsidizing publications in top-tier journals that largely publish articles authored by researchers from developed countries.[73]

Digital technologies offer ample opportunity to facilitate more general knowledge diffusion. For instance, the Bexar County Digital Library in San Antonio, Texas, United States of America, offers digital content, access to online databases and educational resources to increase literacy and digital literacy among communities at lower socioeconomic levels.[74] Other related efforts include the development of educational resources openly available for use by educators and students, without an accompanying need to pay royalties or licence fees.[75] For instance, Latvia has a project on natural sciences and mathematics that has allowed the production of supporting materials for teachers in biology, physics, mathematics and chemistry for secondary school, which are available on the Internet.[76]

Access to knowledge is not only dependent on where information is published but also on where it is created. In this regard, although open access to scientific knowledge is increasing, there are some fields, particularly those related to frontier technologies, in which the role of private corporations producing basic research is growing. While the number of scientific research publications from manufacturing companies has declined in recent years, technology-oriented companies have seen theirs increase.[77] One explanation for this trend is that leading computer scientists and artificial intelligence researchers are increasingly trading their university careers for high-salary careers in the private sector. Most of these researchers are joining the same few private companies, which promise high incomes but, even more so, access to large amounts of data which are required to build artificial intelligence. This could create a brain drain even at top academic institutions, which can reduce the capacity of universities of advancing knowledge and training future researchers.[78]

69 Research4Life, "About Research4Life," 2018, 4, http://www.research4life.org/about/.

70 SciELO, "SciELO.Org - Scientific Electronic Library Online," 2018, http://www.scielo.org/php/index.php.

71 Jacintha Ellers, Thomas W. Crowther, and Jeffrey A. Harvey, "Gold Open Access Publishing in Mega-Journals: Developing Countries Pay the Price of Western Premium Academic Output," *Journal of Scholarly Publishing*, 23 October 2017, https://doi.org/10.3138/jsp.49.1.89.

72 David Dickson, "Developing World Gains Open Access to Science Research, but Hurdles Remain," *The Guardian*, 3 September 2012, http://www.theguardian.com/global-development/2012/sep/03/developing-world-open-access-research-hurdles.

73 Ibid.

74 Contribution from the Government of the United States of America, available at https://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con26_US_en.pdf (accessed 9 April 2019).

75 For more information on open educational resources, see http://unesdoc.unesco.org/images/0021/002158/215804e.pdf (accessed 27 February 2018).

76 Contribution from the Government of Latvia, available at https://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con19_Latvia_en.pdf (accessed 3 December 2018).

77 Nadia Drake, "Basic Science Finds Corporate Refuge," Nature News 509, no. 7498 (2014): 18, https://doi.org/10.1038/509018a.

78 Ian Sample, "'We Can't Compete': Why Universities Are Losing Their Best AI Scientists," *The Guardian*, 1 November 2017, http://www.theguardian.com/science/2017/nov/01/cant-compete-universities-losing-best-ai-scientists.

C. TECHNOLOGY-MEDIATED TEACHING AND LEARNING

Existing and emerging technologies such as the Internet can help build digital competencies by making learning materials accessible to teachers and students. For instance, in Bulgaria the Daskal.eu initiative uses an online platform to connect students and teachers by providing technological tools for setting up virtual classrooms and real-time video streams. Among the users of this platform are freelance teachers, students in need of extracurricular classes and, in some cases, whole schools conducting parts of their classes from a distance.[79]

Remote areas can particularly benefit from digital technology, but often are the last to be connected. In these areas, media centres could serve as educational institutes that, in addition to providing education, can also track and assess the performance of students. For example, Media Centre, developed by the Amazonas State Secretariat of Education of Brazil, helps children living in the Amazon jungle to continue schooling by providing live-streamed lessons. The centre provides technologies and complementary human interaction: while a bidirectional camera enables teachers to interact with students remotely, a local tutoring teacher supports the students' learning by helping to manage classes and administrative issues. Therefore, students benefit from technological advances due to an interactive and engaging learning experience. Since its creation in 2007, Media Centre has benefited more than 300,000 students in 2,300 villages across the Amazonas.[80]

Furthermore, some low-cost private schools are piloting standardized teaching, using technology to achieve more consistent education quality. Founded in 2008, Bridge International Academies is a chain of for-profit primary schools that transmits scripted lesson plans to their teachers, tracks their attendance and gets real-time feedback on students' progress in India, Kenya, Liberia, Nigeria and Uganda. The schools leverage technology to improve educational performance and to streamline administration – the school fees are paid via mobile money providers. First assessments indicate improved learning outcomes, with most students passing nation-wide examinations.[81,82] However, scripted lessons and their school providers are not without controversy. The main criticisms are the robotic nature of scripted teaching as well as a decline in good education because often the hired teachers are unlicensed and only trained in how to convey the scripted content.[83]

New types of schools are harnessing data in adult education: General Assembly and Singularity University, both originating from the United States, are two examples of educational organizations created to cater for the growing demand for digital skills and lifelong learning and for skills to navigate and interact with emerging technologies developing at exponential rates. Their course programmes are adapted based on a data-driven process to increase the usefulness of their classes for direct application in the labour market.[84]

There appears to be great potential in blended learning – complementing traditional classroom pedagogy with digital elements. New technologies promise to make teaching better and more individualized. Artificial intelligence and big data analytics can help teachers make assessments or provide more student-specific feedback by, among others, producing intelligent scoring, interpreting individual profiles and providing advice to learners and teachers by inference procedures.[85] Performance assessment is therefore done in real time, which can help detect knowledge gaps early to ensure long-term learning success; also, feedback is thus flexible

[79] Contribution from the Government of Bulgaria.

[80] J.P. Robinson, R. Winthrop, and E. McGivney, "Millions Learning: Scaling up Quality Education in Developing Countries," *Brookings* (blog), 13 April 2016, https://www.brookings.edu/research/millions-learning-scaling-up-quality-education-in-developing-countries/ (accessed 27 February 2018).

[81] Mauricio Romero, Justin Sandefur, and Wayne Sandholtz, "Can Outsourcing Improve Liberia's Schools? Preliminary Results from Year One of a Three-Year Randomized Evaluation of Partnership Schools for Liberia," Working Paper (Center for Global Development, 7 September 2017), https://www.cgdev.org/publication/partnership-schools-for-liberia.

[82] The Economist, "Bridge International Academies Gets High Marks for Ambition but Its Business Model Is Still Unproven," *The Economist*, 28 January 2017, https://www.economist.com/business/2017/01/28/bridge-international-academies-gets-high-marks-for-ambition-but-its-business-model-is-still-unproven.

[83] The Economist, "Emerging Markets Should Welcome Low-Cost Private Schools," *The Economist*, 28 January 2017, https://www.economist.com/leaders/2017/01/28/emerging-markets-should-welcome-low-cost-private-schools.

[84] The Economist, "Lifelong Learning Is Becoming an Economic Imperative," *The Economist*, 12 January 2017, https://www.economist.com/special-report/2017/01/12/lifelong-learning-is-becoming-an-economic-imperative. (accessed 27 February 2018).

[85] Christine Redecker and Øystein Johannessen, "Changing Assessment – Towards a New Assessment Paradigm Using ICT," *European Journal of Education* 48, no. 1 (2013): 79–96.

Table 4 Potential uses of big data for education

Beneficiaries	Potential contribution of big data
Students in school and university	Allow providing feedback on progress and recommendations on what to do to improve
Teachers	Review and evaluate courses and track students' engagement and achievement
School and university leaders	Review and evaluate institutional and staff performance at the same time
Policymakers	Help learn about institutional and system performance and generate insights for future policy intervention

Source: B Williamson, 2017, *Big Data in Education: The Digital Future of Learning, Policy and Practice* (Sage, London).

and embedded in the teaching process. Table 4 lists additional potential uses of big data for education.

To benefit from technologies in education, it is necessary to have access to reliable and updated ICT infrastructure, ensure the continuous training of teachers and consider the long-term sustainability of the programmes. Also, resources should be adapted and restructured to fit local contexts for youth in low- and middle-income countries, especially in rural regions.[86]

Further, digital learning technologies such as massive open online courses do not guarantee improved educational outcomes, and only through experimentation, monitoring and evaluation can their impact be assessed. Also, when analysing the sustainability and scaling up of e-learning projects, the educational goals and pedagogical approaches appropriate for a specific country or region should be considered.

[86] Contribution from the United Nations Major Group for Children and Youth.

4. INITIATIVES TO HELP BUILD COMPETENCIES

Building the competencies and skills required to understand, adopt, use and create new technologies, particularly ICTs, is central for individuals to participate effectively in and benefit from technologies. Digital competencies, soft skills and access to new technologies, however, are not equally distributed among regions and groups. Therefore, some countries do not have the capacities to leverage technology for development. The rapid pace of technological development requires constant adaptation and flexibility in the types of competencies required. [87, 88] This stresses the need for developing and developed countries alike to put competence building at the forefront of their development strategies. This section describes three areas in which concerted efforts are required to enable and promote the creation and strengthening of digital competencies and soft skills.

A. EDUCATION, TRAINING AND LIFELONG LEARNING

Education and training are central in preparing society and workforce to reap the benefits from rapidly changing technologies. Building the appropriate digital competencies, including soft skills, can only be achieved when training is incorporated at all levels of education (primary, secondary and tertiary, including vocational training) and as part of lifelong updating of skills for the workforce.

Building digital competencies at school

Education policies need to emphasise the importance of digital training for primary, secondary and tertiary education students. However, digital skills training cannot be a static curriculum. Programmes need to be revised regularly to adapt to the changing technological landscape. It is important to consider teaching a broad range of skills, from simple operations of desktop computers and text processing tools to more rigorous courses so that students learn to understand fundamental computing languages, and to establish their algorithmic thinking skills. Box 7 describes several ICT teaching initiatives for primary schools in implementation in countries that are members of the Commission on Science and Technology for Development of the United Nations.

Box 7 ICT initiatives in primary education

The integration of training in ICT skills in school curricula is necessary at all levels, but it is becoming particularly crucial at the primary school level. Exposure to emerging technologies and ICTs at an early age is important in equipping students with the tools needed in a constantly changing technological landscape. Some examples of country initiatives are as follows:

- Launched in 2013, the Digital Literacy Project of Kenya aims at integrating ICTs into teaching and learning for pupils in primary schools, through improving ICT infrastructure, digital content and capacity-building of teachers. As of 2017, the project has trained more than 2,500 teachers and has carried out a needs assessment to ensure the schools have appropriate infrastructure, among other achievements.[89]
- In 2016, the Federal Ministry for Economic Affairs and Energy of Germany started the distribution of a mini-computer, called "Calliope", to interested German primary schools. The device, especially designed for children, aims to give pupils from year three onwards a playful approach to the digital world. Children can use the mini-computer to build a robot, transmit messages, make it communicate with other devices and transmit programmes generated on their own to their mini-computer. In the midterm, 75 per cent of Calliope minis are expected to be bought by schools through procurement via Cornelsen, Conrad and Amazon.[90]
- In the scope of international partnerships and development efforts, the Federal Ministry for Economic Cooperation and Development (BMZ) of Germany is supporting children's coding skills in Africa. In 2016, BMZ supported the Africa Code Week in Rwanda – a joint initiative by SAP, the Cape Town Science Centre and the Galway Education Centre. This initiative has provided coding lessons for 50,000 pupils.[91]

Encouraging girls to study and pursue careers in science, technology, engineering and mathematics (STEM) in both developed and developing countries can help build intermediate- and advanced-level digital

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87 UNCTAD, "Information Economy Report: Digitalization, Trade and Development."

88 The Economist Corporate Network, "Shaping the Future of Work: Technology's Role in Employment".

89 Contribution from the Government of Kenya, available at https://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con18_Kenya_en.pdf (accessed 9 April 2019).

90 Contribution from the Government of Germany, available at https://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con17_Germany_en.pdf (accessed 9 April 2019), and https://calliope.cc/en/idee/mission (Retrieved on 4 October 2018).

91 Contribution from the Government of Germany.

skills.[92] In higher education, girls represent 35 per cent of students enrolled in these fields. This skewed enrolment arises for different reasons, including societal and parental attitudes towards the abilities of boys and girls, perceptions that girls are less scientifically able, access to education and bias in teaching material and curricula.[93] Moreover, women who enter these professions leave disproportionately more than men, known as the "leaky pipeline problem".[94]

The low participation of girls and women in STEM fields has increased the focus on curriculum content of these subjects as a potential driver of the divide. To bridge the gender divide in coding, Code.org, a non-profit organization in the United States of America, focuses not only on teaching coding skills to middle and high school students but starts with a wider context of teaching logic and data to bring in more diverse interests and ensure an equal footing for participants.[95] Furthermore, tertiary education institutions are reforming their courses. The content is being shifted to emphasize the relevance of computer science for society – which, according to researchers, makes courses more attractive to female students.[96] Another way of shaping STEM education is by integrating the broad field of the arts into STEM to potentially help increase women's engagement in these fields.[97]

There is important potential for ICT in helping to deliver digital competencies through formal education. However, people living in developing countries often cannot enjoy the benefits of technology-assisted training on digital skills due to the existing gaps in schools' ICT infrastructure and equipment and in teaching staff and resources. For instance, estimations suggest that in developed countries the proportion of primary and secondary teachers with good ICT skills is on average three percentage points lower than that of other tertiary educated professionals, while being much higher than the skills of the general adult population.[98]

Unlike traditional subjects, teaching digital skills requires special pedagogical approaches. 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' ICT knowledge, many projects that aim to improve education in developing countries emphasize teacher training in digital competencies.[99] The initiatives presented in box 8 illustrate how teacher training in ICT and digital technologies as a pedagogical strategy is slowly becoming an integral part of teacher training.

Existing software and platforms for digital skills' learning are predominantly designed for social and cultural contexts in developed countries.[100] Therefore, to fit classrooms and living realities of students in developing countries, more open source software and online platforms need to be adapted and localized. Also, training programmes targeted at indigenous communities need to integrate content relevant to the traditions, culture and history of the local community to facilitate ICT learning and ICT integration into daily life.[101]

Box 8 Teacher training initiatives

Integrating ICT into teaching creates the basis to instil digital skills in students. Many countries undertake teacher training initiatives to promote the use of ICTs in school. Some examples are:

- In Turkey, the FATIH Project was designed to provide equal opportunities in education and to improve technology infrastructure in schools to ensure effective use of information technology in educational processes. The project includes a teacher training pillar under which 457,000 teachers received in-service training by October 2017.[102]
- In Uganda, the Ministry of Education and Sports and the Uganda Communications Commission set up ICT laboratories in more than 1,027 secondary schools. Teachers received training to be able to teach computer studies in September 2017.[103]

92 Broadband Commission for Sustainable Development, "Working Group on Education: Digital Skills for Life and Work.".

93 UNCTAD, "Applying a Gender Lens to Science, Technology and Innovation," UNCTAD Current Studies on Science, Technology and Innovation (Geneva: UNCTAD, 2011), http://unctad.org/en/Docs/dtlstict2011d5_en.pdf.

94 Broadband Commission for Sustainable Development, "Working Group on Education: Digital Skills for Life and Work.".

95 Leslie Hook, "US [United States] Tests Strategies to Interest Girls in Computer Science," *Financial Times*, 9 March 2018, https://www.ft.com/content/1009cbda-fb7e-11e7-9bfc-052cbba03425.

96 Linda J. Sax et al., "Anatomy of an Enduring Gender Gap: The Evolution of Women's Participation in Computer Science," *The Journal of Higher Education* 88, no. 2 (2017): 258–93, https://doi.org/10.1080/00221546.2016.1257306.

97 Sophia Lepore, "Why Art Is the Key to Closing the STEM Gender Gap," *STEM Diversity Network* (blog), 9 December 2016, https://stemdiversity.wisc.edu/featured/why-art-is-the-key-to-closing-the-stem-gender-gap/. (accessed 27 February 2018).

98 OECD, "Teachers' ICT and Problem-Solving Skills," March 2016, https://doi.org/10.1787/5jm0q1mvzqmq-en.

99 Lesley Bartlett et al., "ICT in Education."

100 Michelle Eady, "Eleven Design-Based Principles to Facilitate the Adoption of Internet Technologies in Indigenous Communities."

101 Ibid.

102 Contribution from the Government of Turkey.

103 Contribution from the Government of Uganda. Info retrieved from: http://www.ucc.co.ug/retooling-of-teachers-to-teach-computer-studies/.

- The CanCode programme (2017–2018) of Canada supports educational opportunities for coding and digital skills development to Canadian youths from kindergarten to grade 12. The programme considers a teacher training initiative in digital skills and coding for 500 teachers across the country.[104]
- In 2014, the Plurinational State of Bolivia implemented the Educa Innova initiative, which provides teachers and educators with a space to share knowledge and experiences related to ICT use in classrooms. As of 2017, Educa Innova had reached more than 14,430 teachers.[105]

Digital competencies as part of vocational training

Introducing professional digital skills training, such as coding, data analysis and e-business skills, can help young people seize new opportunities offered in the future job market. Vocational training can help to provide these competencies because of its applied nature and the fact that it directly prepares students for employment. To ensure meaningful digital skills training, vocational education schools need to cooperate closely with industries to keep their curricula in line with industries' technological development and thus their arising labour force needs.

Creating interfaces between schools and industries can help facilitate this collaboration. This type of joint curriculum development is already in place in traditionally strong vocational education systems, such as Switzerland. Swiss State partners and sectoral professional organizations are jointly responsible for vocational education content. This cooperation ensures updated curricula which are relevant for industries' needs.[106] Consequently, in these systems with institutionalized curricula updates, industry leaders at the technology frontier contribute their experience with new technologies and are the ones to demand up-to-date teaching for new technology adoption. Through this integration in country-wide curricula, innovative skills diffuse more widely and quickly in an economy.[107] Public-private collaboration can identify new vocational training needs and create the required apprenticeships and training. For instance, in 2018, Switzerland introduced a new apprenticeship as ICT operator and an advanced diploma for ICT security experts. Other examples are the trainings on coding in SCRATCH language, robotics, 3D design and web design offered by the Office of Electronic Communications of Poland. The courses also aim to strengthen the development of creative and analytical thinking. Additionally, the programmes are flexible and are tested in non-traditional settings such as in hospitals or even on the go during a train journey.[108]

Examples of vocational training for digital skills, beyond programming, also exist. In the United Kingdom of Great Britain and Northern Ireland, the National College for Digital Skills provides digital skills training, with a special focus on female students and students from lower-income backgrounds. The college aims to teach its students high-level digital skills to seek employment in sectors with skill shortages.[109] In 2012, Germany launched a funding programme on "Digital Media in Vocational Training" to support vocational learning using digital media.[110] The Industry 4.0 project of Turkey aims to provide young students in vocational schools with skills training and knowledge in emerging technologies, such as the Internet of things. Also, the efforts of Turkey in increasing employment include the implementation of non-formal vocational ICT training through partnerships with private education institutions. The initiative will train 10,000 individuals annually.[111]

Digital competencies and lifelong learning

Estimations suggest that by 2030, 75 to 375 million workers, representing 3 to 14 per cent of the global workforce, will need to switch occupational categories.[112] While up to 65 per cent of Generation Z, the cohort born after the

[104] Contribution from the Government of Canada, available at https://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con16_Canada_en.pdf (accessed 4 December 2018).

[105] Contribution from the Government of Bolivia, available at https://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con14_Bolivia_es.pdf (accessed 4 December 2018).

[106] KOF Swiss Economic Institute, "KOF Factbook Education System Switzerland," KOF Factbook Education System Series (Zurich: ETH Zurich, 2015), https://www.kof.ethz.ch/en/publications/Factbooks_Edu_Sys.html.

[107] Christian Rupietta and Uschi Backes-Gellner, "How Firms' Participation in Apprenticeship Training Fosters Knowledge Diffusion and Innovation," Working Paper (Swiss Leading House on Economics of Education, 2018).

[108] Contribution from the Government of Poland.

[109] Contribution from the Government of the United Kingdom.

[110] Contribution from the Government of Germany.

[111] Contribution from the Government of Turkey.

[112] James Manyika et al., "What the Future of Work Will Mean for Jobs, Skills, and Wages." (accessed 27 February 2018).

mid-1990s, will have jobs that do not exist yet.[113] Consequently, it becomes increasingly important to think more in terms of skills – and less in terms of jobs – and match those skills with labour market needs. In a context of rapid technological advances digital skills training needs to stay up to date to provide relevant professional skills for adult students. Therefore, it is essential to develop the skill to learn continuously. Along these lines, 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 seek in an environment of rapid technological change.[114] Box 9 describes country examples of programmes aimed at providing on-the-job training.

One important factor that hinders lifelong learning in adults is illiteracy. Recent technological advances have made literacy a vital basis upon which to build further skills development. In developing countries, the economic and social cost incurred by functional illiteracy is estimated to be above US$5 billion.[115] Traditional community centres such as libraries could provide new training programmes for members of a community. For example, as part of the National Strategy for Lifelong Learning (2014–2020) of Bulgaria, public libraries provide digital skills training for various social groups.[116]

Women require digital literacy to either compete with men in the job market, carve their own niches, or manage everyday tasks. In this vein, the Government of Kenya aims to extend Internet access to local communities, which will include people with disabilities and women. Furthermore, as part of the country's strategy for capacity-building for citizens' digital literacy comparable digital literacy rates for women are supposed to be ensured.[117] In Pakistan, digital learning is used to teach reading and other basic skills. The Citizens Foundation has developed an online platform to facilitate literacy education for women and out-of-school girls in rural areas, based on a prior assessment of women's digital educational needs of the country.[118]

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

Box 9 On-the-job training

To improve workers adaptability and to keep up with the growing demands of new technologies, employers are increasingly providing workers with training in ICTs.

On-the-job training is part of efforts by Bulgaria to improve the technical competence and efficiency of the administration. The Institute of Public Administration of Bulgaria provides training for civil servants from all levels (central, regional and local) of the public administration. "Blended learning approaches" and fully distant learning provide civil servants with the opportunity to improve their skills while saving scarce public resources on travel expenses. Training includes courses in e-governance, information security, open data, electronic signatures and documents, cloud technologies and even smart-city management. Particularly, the training benefits regional and local administrations. In 2016, 62 per cent of participants in online educational modules were from these administrative levels. In 2014, 5,500 civil servants completed IT and e-governance programmes, 25 per cent of the number of total participants in training activities that year.[119]

In the United States, some workers in certain rural areas need to develop advanced computer skills due to automation. Non-profit organizations, such as the Eastern Kentucky Concentrated Employment Program and TechHire, deliver ICT training for a sustainable career in the digital economy within the region. TechHire is a consortium of technology-related employers who use workforce development, work-based volunteer internship activity and on-the-job training placements to build new skills.[120]

113 Mara Swan, "This Skill Could Save Your Job – and Your Company," World Economic Forum, 2016, https://www.weforum.org/agenda/2016/08/this-little-known-skill-will-save-your-job-and-your-company/.https://www.weforum.org/agenda/2016/08/this-little-known-skill-will-save-your-job-and-your-company/ (accessed 8 June 2018).

114 Ibid.

115 World Bank, "World Development Report 2019: The Changing Nature of Work" (Washington, DC.: World Bank Group, 2018), http://pubdocs.worldbank.org/en/816281518818814423/2019-WDR-Draft-Report.pdf.

116 Contribution from the Government of Bulgaria.

117 Contribution from the Government of Kenya, available at https://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con18_Kenya_en.pdf (accessed 4 December 2018).

118 UNESCO, "Community Engagement and Online Literacy Empower Girls and Women in Pakistan," 4 September 2017, https://en.unesco.org/news/community-engagement-and-online-literacy-empower-girls-and-women-pakistan. (accessed 28 February 2018).

119 Contribution from the Government of Bulgaria.

120 Contribution from the Government of the United States of America.

B. ENABLING ENVIRONMENT TO SUPPORT SKILLS DEVELOPMENT

The creation of an environment facilitates building digital competencies and contributes to leverage their potential. An enabling environment is promoted through investment in infrastructure, institution development and collaboration among stakeholders, among others.

Investment in digital infrastructure

A fundamental element of the digital capacity of countries is their digital infrastructure. Only those that are connected and have the required capabilities will be able to take advantage of the development opportunities offered by technological changes. Therefore, in addition to investing in capacity-building, it is essential to reduce the digital divide. This can be achieved, for example, by investing in digital infrastructure. Estimates show that almost 4 billion people – more than half the world's population – do not have Internet access. Particularly noteworthy is the gender dimension of this digital divide. Although the gap has narrowed in terms of using the Internet (currently 12 per cent), it has widened in Africa (25 per cent) and in the least developed countries, where only one out of seven women use the Internet, compared with one out of five men. [121]

Broadband connectivity in developing countries, when available, tends to be relatively slow and expensive, limiting the ability of businesses and people to use it productively. In LDCs, landlocked countries and small island developing States, geographical and resources constraints, and low population densities make rapid returns on capital for building extensive Internet infrastructure to remote regions more difficult for private investors. Infrastructure investment is critical to tackling inequalities in Internet access. In this regard, international financial institutions and development partners have an important role to play, alongside private sector businesses and governments.

Investment in digital infrastructure also includes investing in data resources and the facilities and capabilities for collecting, analysing and using big data. Efforts in this area include building national big data centres, achieving full broadband coverage in developing countries and investing in regional high-speed computing and processing facilities for big data analysis. For instance, online platforms and education applications can help countries educate and train the workforce and citizens. However, to make data to work for societies, it is also necessary to build analytical capabilities in policymaking and decision-making processes. For instance, one of the outcomes of the Agriculture Rural Development and Land Reform Phakisa process, part of Operation Phakisa ("hurry up") of South Africa, is improvement of decision-making at all levels through ICTs. These technologies are used to monitor and evaluate the progress of community-level development initiatives to then feed back into the policymaking process at all government levels.[122]

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: 96 per cent of students in OECD countries have computers at home, but only 72 per cent reported using ICTs at school.[123] 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. As a way to reduce the digital access gap, ConnectHome, a public–private collaboration in the United States of America, provides free or low-cost broadband access, devices and digital literacy training to low-income families, aiming to narrow the digital divide at home.[124] Similarly, in Canada, the Affordable Access programme supports Internet service providers to offer affordable Internet packages and refurbished computers to low-income families.[125]

Policy and institutional development

To build digital competencies, it is essential to have appropriate institutions that set rules creating incentives that motivate workers, management, firms, universities and other entities to adopt and develop the necessary skills. These institutions include laws and regulations, organizations such as vocational and community schools to support professional training and lifelong learning, universities and research centres that develop digital technologies and their applications, and non-governmental and social organizations that provide support to the wider society for digitalization, adoption and use.

[121] ITU, "ICT Facts and Figures 2017" (International Telecommunication Union, July 2017), http://www.itu.int:80/en/ITU-D/Statistics/Pages/facts/default.aspx.

[122] Contribution from the Government of South Africa.

[123] OECD. "Students, computers and learning".

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

[125] Contribution from the Government of Canada.

Other efforts in areas such as taxation, financing, industry and labour market policies can also help develop an incentive structure that encourages and facilitates investment and labour participation in the digital economy. A description of selected national strategies aimed at equipping countries with the resources needed to benefit from technological advances is provided in box 10.

It is also essential to consider culture and entrepreneurship when designing digital competencies programmes, especially in the emerging technology-intensive new economy and in the informal sector. The right policies can especially open (labour) market opportunities for women in the technology-driven economy. For instance, Internet access can help women to sell their produce and merchandise to markets further away at higher profit. Moreover, with institutional incentives in place, digital opportunities can offer employment opportunities to women that might have been excluded from the labour market for cultural reasons. For instance, in Pakistan, doctHERS offers digital consultations to remote regions from certified female doctors who used to be predominantly stay-at-home wives, thereby offering income opportunities for one side and better service provision for the other.[126]

Box 10 Selected national strategies aimed at increasing digital competencies of countries

- Bulgaria. Digital Bulgaria 2020 Programme: Sets forth the country's current priorities 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 workers in the high-technology sector.
- Canada. Innovation and Skills Plan: Aims to make Canada a world-leading centre for innovation, help create more well-paying jobs and strengthen and expand the middle class. It includes equipping citizens with the tools, skills and experience they need to succeed in the workforce, now and in the future.
- Kenya. National ICT Master Plan: Road map based on the ICT theme, "Strengthening the foundation for a knowledge-based economy". Considers strategies to enhance public value, development of ICT businesses and strengthening of ICT as a driver of the industry.
- Portugal. National Digital Competences Initiative e.2030 (INCoDE.2030): Brings together public and private organizations to generalize digital literacy, stimulate employability, professional training and specialization in digital technologies and applications and ensure strong participation in international research and development networks and the production of new knowledge in digital areas.
- South Africa. Revised National Broadband Policy and Broadband Strategy: Aimed at ensuring universal access to reliable, affordable and secure broadband infrastructure and services by 2020 and stimulating sustainable uptake and usage of ICTs.
- Uganda. Digital Uganda Vision: Addresses issues related to infrastructure support, policy framework, access to ICTs, capacity development, collaboration among various agencies, common access to government services by citizens, delivery of services and participative access.
- United Kingdom. Digital Skills and Inclusion Policy: Aims to ensure that everyone who is able to participate in the digital economy does so.
- United States of America. Federal Open Data: An open government data initiative that contributes to modernizing government and improving the delivery of services provided by government, industry and non-governmental organizations.

Source: Contributions from Member States of the Commission on Science and Technology for Development.

C. COLLABORATION AMONG STAKEHOLDERS

The improvement of digital competencies requires extensive investment in training staff, designing curricula and providing information centres, all of which call for more in-depth collaboration. There are several areas in which collaboration among stakeholders can contribute to the strengthening of digital competencies in countries, for instance, through public–private partnerships in delivering digital skills and building digital infrastructure, and through international collaboration among stakeholders for capacity-building and research.

Public–private partnerships

Public–private partnerships can support training provision, infrastructure development and building of data facilities. Technology companies are already playing important roles in some developed countries to support the training and teaching of digital skills. For example, Microsoft works with the Government of the United Kingdom to train civil servants how to use new technologies such as cloud services.[127] Collaboration among stakeholders can also contribute to sharing information on demand and supply of skills digital competencies, provide on-the-job training and internships, and introduce cutting-edge technological skills to learners. For example, Portugal established a

[126] Saadia Zahidi, "Working Muslim Women Are a Trillion-Dollar Market," World Economic Forum, 23 May 2018, https://www.weforum.org/agenda/2018/05/muslim-women-trillion-dollar-market-saadia-zahidi/.

[127] https://news.microsoft.com/en-gb/2017/01/26/microsoft-launches-digital-skills-programme-for-the-uk/ (accessed 27 February 2018).

partnership with several universities, including the Massachusetts Institute of Technology, Carnegie Mellon University and Indian Institutes of Technology, to establish networks that support the enhancement of digital competencies.[128]

International collaboration

International collaboration can contribute to the strengthening of digital competencies in countries. Examples thereof include coding courses for teachers and students implemented in Rwanda by Germany and other stakeholders in 2016[129] and the international online forum Code Club, supported by the Raspberry Pi Foundation, a charity based in the United Kingdom. This organization works with institutions in over 100 countries to provide training materials for educators and volunteers around the world to teach children how to code.[130]

Collaboration among Governments, businesses and other stakeholders can also help build ICT infrastructure; accelerate the development of digital skills; build storage and analysis capabilities; and develop regulations and ethics in data collection, usage and open access. For instance, Uganda built an information access centre with the assistance of the Government of the Republic of Korea to facilitate e-government initiatives.[131] Partnerships such as EQUALS – a global partnership for gender equality, led by ITU and the United Nations Entity for Gender Equality and the Empowerment of Women – can also play a useful role in this regard (for more details, see box 11).[132] Additionally, collaborations also extend to technology companies. For example, by initiating the last Thursday in April every year as "International Girls in ICT Day", ITU facilitates an international environment for public and private sectors to be involved in the global goals of enhancing digital skills for all.[133, 134] 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 by bringing MOOC education into developing countries and designing online courses that meet the needs of the future workforce. [135]

Box 11 EQUALS – the global partnership for gender equality in a digital age

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

This 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 – aims to focus the existing efforts of different stakeholders in this domain. The partnership is an important multi-stakeholder approach to harmonize skills programmes for women and girls that help to tackle the gender digital divide.[136]

Under the EQUALS Leadership Coalition – the International Telecommunication Union (ITU), UN-Women and the International Trade Centre (ITC) and the United Nations Conference on Trade and Development (UNCTAD) – have set five priorities that are closely related to women's engagement and leadership in ICTs and the technology industry. These priorities focus on digital entrepreneurship, recruitment, retention, promotion and content. Building upon existing initiatives, such as the Women Empowerment Principles (WEPs),[137] the SheTrades[138] platform and the Project Include,[139] the coalition aims to identify good practices in leading ICT and technology companies. These examples will contribute to the formulation of specific guidelines encouraging the leadership of women in the industry.

[128] Contribution from the Government of Portugal, available at http://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con21_Portugal_en.pdf (accessed 27 February 2018).

[129] Contribution from the Government of Germany, available at http://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con17_Germany_en.pdf (accessed 27 February 2018).

[130] https://www.codeclubworld.org/about/countries/ (accessed 27 February 2018).

[131] Contribution from the Government of Uganda, available at http://unctad.org/meetings/en/Contribution/CSTD_2018_IPanel_T2_DigitalComp_con24_Uganda_en.pdf (accessed 27 February 2018).

[132] EQUALS, "EQUALS Global Partnership to Bridge the Digital Gender Divide," (accessed 18 September 2018), https://www.equals.org/.

[133] UN-Women, "International Girls in ICT Day," 26 April 2017, http://www.unwomen.org/news/stories/2017/4/feature-international-girls-in-ict-day.

[134] ITU, "A Bright Future in ICTs: Opportunities for a New Generation of Women" (Geneva: International Telecommunication Union, 2012).

[135] Michael Trucano, "MOOCs in Africa," Text, *EduTech -- A World Bank Blog on ICT Use in Education* (blog), 12 April 2013, https://blogs.worldbank.org/edutech/moocs-in-africa.

[136] Contribution from the Government of Germany.

[137] EmpowerWomen, "Women Empowerment Principles (WEPs)," EmpowerWomen, accessed 18 September 2018, www.weprinciples.org.

[138] See https://www.shetrades.com (accessed 18 September 2018).

[139] See http://projectinclude.org/ (accessed 18 September 2018).

Also, multi-stakeholder forums such as the Commission on Science and Technology for Development can contribute to exploring technological advances and their policy implications for countries in terms of capacity-building. In addition, they can facilitate and promote formal collaboration between countries and stakeholders' groups, as well as facilitate the exchange of good practices and lessons learned in promoting digital competencies.

5. KEY FINDINGS AND POLICY CONSIDERATIONS

Digital technologies are already producing an impact on many areas of social and economic life, including employment opportunities. The deployment of existing and emerging technologies offers potential to support the achievement of the 2030 Agenda for Sustainable Development, particularly in areas such as health, education, agriculture, new enterprise development, gender equality and environmental sustainability. However, rapid technological change also creates concerns and challenges, since new technologies can also increase inequalities. Building digital competencies can help countries maximize the benefits and reduce the negative effects of new technologies in societies.

This final section summarizes the issues addressed in this study and discusses the implications for national government policies and for the United Nations Commission on Science and Technology for Development.

A. BUILDING DIGITAL COMPETENCIES THROUGH EDUCATIONAL FRAMEWORKS

Education policy needs to accommodate new requirements for digital skills' training schemes, making digital competencies part of the education goals. Depending on the type of skills that needs improving, policymakers can shape training of digital competencies at three points in time of an individual's learning career: incorporating digital skills training at school, providing on-the-job training and embedding digital skills training in lifelong learning.

Policies should incorporate the provision of digital competencies and complementary soft skills, including entrepreneurship. This should take into consideration best practices and local contexts and needs, and ensure that education is technology neutral.[140] Also, efforts need to be devoted to promoting the study of science, technology, engineering and mathematics, particularly among female students, while also recognizing the importance of studies that incorporate the arts within traditional technical subjects. Training also should be provided to teachers, particularly in areas such as digital skills and computational thinking. Capacity-building in these areas can be provided in combination with training in other general skills, such as entrepreneurship and soft skills, and should consider mandatory training in gender bias awareness.

Policies should also support firms and other stakeholders in the provision of training of broad digital competencies for the workplace and in wider social life, lifelong learning capabilities and entrepreneurship skills.

B. CREATING AN ENABLING ENVIRONMENT: INVESTMENT IN INFRASTRUCTURE AND INSTITUTIONAL DEVELOPMENT

While direct interventions through education and training are critical for digital competencies, the creation of an enabling environment that makes actual access possible through investment in infrastructure and institutional development is also crucial. Policies aimed at establishing adequate ICT infrastructure include promoting investment in infrastructure and data resource capabilities, including facilities for data collection, storage and transmission; capabilities for big data analysis and decision-making; and appropriate tools to provide and benefit from open government data. Initiatives that encourage and facilitate investment and labour participation in the digital economy include the promotion of online platforms, community activities and financial incentives (for example, tax breaks and low-interest bank loans), financial support for small and medium-sized enterprises engaged in digital technology, promotion of e-business and entrepreneurship, and automation or digitalization of existing businesses.

The development of digital competencies also requires the appropriate institutions to set rules that create incentives that motivate workers, firms, universities and other organisations to adopt and develop the skills needed. These institutions include laws and regulations, training institutions, research centres, non-governmental organizations and social organizations that provide support to society for the creation, adoption, adaption and use of technologies.

Furthermore, efforts to identify technological trends can improve the capacity of people, organizations and Governments to adapt to change. In this context, implementing support mechanisms to identify trends

[140] In other words, education that does not promote specific technologies.

in ICT development and skills needs, such as foresight, can help the design and adaptation of capacity-development policies and can help workers and organizations meet current and emerging demands for competencies.

C. ESTABLISHING INITIATIVES THAT PROMOTE ENTREPRENEURSHIP IN THE DIGITAL ECONOMY

Digital technologies offer new scope for entrepreneurship because digitalization brings about fundamental changes to the organization of production, how businesses are set up and who can become an entrepreneur, even without a lot of capital. Special attention should be devoted to policies and partnerships that target the creation and strengthening of digital competencies and skills in youth and women.

D. SUPPORT COLLABORATION AMONG ALL STAKEHOLDERS, INCLUDING AT THE INTERNATIONAL LEVEL

Collaboration among stakeholders, including public–private partnerships, should be promoted to support infrastructure development and the building of data facilities.

Moreover, improving digital competencies particularly needs extensive investment in training staff, designing curricula and providing information centres, all of which can benefit from collaboration among stakeholders. In this context, international organizations can facilitate public–private conversations and collaborations on digital competencies. Multi-stakeholder forums, such as the Commission on Science and Technology for Development, can help to encourage knowledge sharing between Member States and other stakeholders. They can also support countries' efforts to build capacity develop, use and deploy new and existing technologies.

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