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# Digital Skills *Insights*
2020

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## Acknowledgements

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Contributors to this issue are:

Marnie McDonald (**Editor**)

Susan Teltscher (**Introduction**)

**Authors**

Thomas Bourgeau
Ingrid Brudvig
Elinor Carmi
Hakima Chaouchi
Kiran Garimella
Ridhi Kashyap
Eleanor Lockley
Goodiel Moshi
Hilda Mwakatumbula
Babatunde Okunoye
Alicja Pawluczuk
Nanjira Sambuli
Estephanie Silva-Avellaneda
Elyn L. Solano-Charris
Dhanaraj Thakur
Lav R. Varshney
Carolina Velásquez-Mora
Florianne C.J. Verkroost
Ingmar Weber
Bridgette Wessels
Simeon J. Yates
Emilio Zagheni



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# Foreword

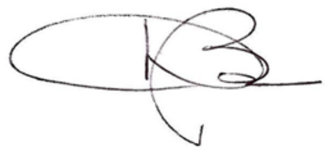
In the wake of the global pandemic, the importance of digital skills has never been so evident, nor so urgent. As those lucky enough to enjoy fast connectivity took refuge from the global health emergency by moving to a virtual environment to support economic continuity, education and interpersonal contact, those lacking access to digital networks and skills have been left even further behind.

As the world struggles to fashion a 'new normal' for the post-pandemic era, it is more apparent than ever that the ability to leverage digital technologies will be vital to the future resilience and prosperity of nations, communities and individuals. This timely new edition of Digital Skills *Insights* focuses on pertinent topics related to this pressing global need for digital capacity building and skills development.

Now in its fourth year, Digital Skills *Insights* aims to provide new perspectives and enhance knowledge among the ITU stakeholder community on issues impacting digital learning and skills development, featuring eight new articles from leading international experts, divided into two broad areas. The first set provides a broad overview of the discussion on digital skills demand and supply, new skills requirements in emerging job markets, and challenges related to future digital skills requirements. Issues covered include digital skills shortages in global labour markets, and how skills needs evolve in line with new technologies. They emphasize the need for accurate forecasts of digital skills requirements, and flexible digital skills acquisition approaches.

The second set of articles focuses on digital skills and the digital gender divide. These pieces discuss pertinent interlinkages between digitization, jobs, gender and digital skills development, highlighting the importance of collaborative efforts in addressing digital skills requirements and raising thought-provoking questions about the participation of women and girls in science, technology, engineering and mathematics (STEM) subjects. Questions raised include whether there is enough data to determine if variations in digital skills gender gaps are affected by increasing diversification of jobs in the IT sector, and why do women continue to be left behind in terms of direct participation in the digital economy, despite accelerating connectivity and access to mobile devices.

I hope this publication will stimulate and contribute to the important ongoing discussions among ITU's membership, including policy-makers, academics and stakeholders involved in the digital skills ecosystem, on the best strategies to rapidly strengthen the capacities and skills required to profit fully from the benefits of digital transformation.



Doreen Bogdan-Martin
Director, Telecommunication Development Bureau (BDT)
International Telecommunication Union

# About this publication

"Digital Skills *Insights*" (called "Capacity Building in a Changing ICT Environment" until 2018) is an online publication which puts together scholarly articles with a focus on the impact of digital transformation on capacity and skills development. It covers a wide range of topics that may affect people and their skills development, such as artificial intelligence (AI), the Internet of Things (IoT), big data, telecommunication regulatory issues, smart cities/societies, digital competencies, open source learning and intellectual property rights, etc. The publication seeks to provide a body of knowledge that will facilitate academic research and innovation exploring the linkages between emerging technologies and capacity development. It features current and new thinking that will contribute to informed policy debates and decisions among policymakers and regulators, as well as help the private sector to anticipate and plan for human capital requirements and skills development in order to remain competitive in a rapidly changing digital environment. The publication, which is released annually, features contributions from academic scholars and other researchers from all over the world. The purpose of the articles is to share views and scholarly opinions that will stimulate debate among its readers. Articles published are subjected to a quality assurance process through a peer review exercise. This publication is available on the ITU Academy platform. The published articles will also be subject to discussion at forums organized from time to time for members of ITU. Those interested in submitting an article for consideration in future editions of "Digital Skills *Insights*" should contact the ITU Capacity and Digital Skills Development Division at hcbmail@itu.int

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# Introduction

*By Susan Teltscher*

## Digital skills and COVID-19

COVID-19 has impacted life around the globe for most of 2020. It has caused a global health, economic and social crisis whose impact is likely to be felt for generations to come. It has also demonstrated the vital role of digital technologies. With a significant share of the population being confined at home during various periods of the pandemic, the need for good Internet connectivity, appropriate digital tools and digital skills to use those tools has surfaced rapidly. A large number of activities related to work, school/education, caring, shopping, socializing and other pastimes, among others, moved from the physical to the virtual world. Internet-based companies such as Amazon, Zoom, Netflix and TikTok experienced record growth in sales and customer base, although others such as travel and transport-related platforms faced a steep decline.

This accelerated digital transition also revealed the challenges that still exist when it comes to connecting households and people, and the digital skills required to participate effectively in the online world – particularly in developing countries. With 90 per cent of schools closed and 1.6 billion children out of school during the pandemic,[1] many educational institutions, teachers and pupils/students were confronted for the first time with remote teaching and online learning as the only way to continue education. In many developing countries, no teaching and learning took place at all due to insufficient or costly Internet access, lack of computers or laptops, and lack of remote teaching facilities and abilities, among others.

In the world of work, employers were forced to close offices. According to International Labour Organization estimates, workplace closures in the second quarter of 2020 resulted in the loss of 305 million jobs worldwide and 94 per cent of the global workforce was affected due to COVID-19. It has hit those in precarious jobs hardest, such as the 2 billion workers in the informal economy, of whom 1.6 billion face a threat to their livelihoods.[2]

Organizations whose business could be carried out digitally moved towards remote working environments. The International Labour Organization estimated that about 18 per cent of workers are doing jobs and are in locations which lend themselves to teleworking. These numbers are significantly higher in developed countries, in large organizations and among higher-income workers.[3] However, teleworking also brings challenges related to connectivity, equipment and skills – apart from those related to home-based working arrangements in combination with child and elder care responsibilities, etc.

Recognizing the benefits of working from home, public and private sector organizations alike are now reconsidering how they organize their work and remote working arrangements may continue to some extent beyond the pandemic.[4] Others are reflecting on accelerating the use of technologies to enable new ways of working in the light of their pandemic experience.

This accelerated speed towards digitization in the corporate sector goes hand in hand with a growing demand for employees with specialized digital skills who need to install, maintain and secure information and communication systems and provide technical support to the workforce. In addition, the pandemic spurred innovation in digital tools and platforms and increased digitization of business processes, products and services. As the pandemic continues, there is growing focus on the use of digital technologies.

As a result of these developments, the need for a digitally competent population and the demand for a digitally skilled workforce has grown even more pronounced. Policy-makers, industry, academia and other educational institutions, as well as the international development community are recognizing this need and developing new strategies to cater to it. Programmes and initiatives addressing the digital skills gap are mushrooming.

## Digital skills gap

Even before the pandemic broke out, the digital skills gap existed and demand for digitally skilled workers was high across all levels of skills (basic, intermediate and advanced skills). The pandemic has, however, heightened the digital skills gap. The following provides a snapshot of recent studies by different regional and global organizations that try to capture the digital skills gap and the shortage of skilled workers on the labour market. While most of the data are from more developed countries, a number of business surveys describe the situation around the globe.

According to studies carried out by the European Commission:[5]

- In Europe, 42 per cent of citizens do not have basic digital skills even though most jobs require such skills. Some 37 per cent of people in the labour force – farmers, bank employees and factory workers alike – also lack sufficient digital skills despite the increasing need for such skills in all jobs.
- 64 per cent of large enterprises and 56 per cent of small and medium-sized enterprises that recruited ICT specialists in 2018 reported that these vacancies were hard to fill.
- Before the pandemic, it was estimated that 1 million new jobs would be created in the European Union by 2030 and 60 million new jobs worldwide in the next five years as a result of the green and digital transitions (European Commission, 2020).

According to World Economic Forum research:[6]

- At least 133 million new workplace roles may be generated globally by 2022 as a result of the new division of labour between humans, machines and algorithms.
- There is a strong demand for technical skills like programming and app development, along with skills that computers cannot easily master such as creative thinking, problem-solving and negotiating.
- More than half (54 per cent) of all employees will require significant reskilling by 2022.
- Closing the global skills gap could add USD 11.5 trillion to global GDP by 2028.
- Based on LinkedIn Learning, the top five hard skills companies need are: cloud computing, artificial intelligence (AI), analytical reasoning, people management and user experience design.

According to a business survey carried out by Capgemini (2017):

- 55 per cent of organizations worldwide acknowledge that the digital skills gap is widening.

Results from a global skills survey carried out by PwC:[7]

- 79 per cent of global CEOs are concerned about the availability of key digital (Fourth Industrial Revolution) skills, and in Africa that figure jumps to 87 per cent. A total of 45 per cent are 'extremely concerned'.
- 53 per cent of workers believe automation will significantly change or make their job obsolete within the next 10 years (only 28 per cent feel this is unlikely).
- 34 per cent of adults without post-secondary school education or training say they are not learning any new digital skills, compared with 17 per cent of college graduates.
- 30 per cent of jobs are at risk from automation by the mid-2030s.

Results from the Asia-Pacific Economic Cooperation Closing the Digital Skills Gap survey:[8]

- 75 per cent of respondents – comprised of employers, government officials and academics – report a significant skills mismatch.
- More than 50 per cent of respondents also report that government agencies have a weak understanding of the digital skills landscape.

According to a study on sub-Saharan Africa by the International Finance Corporation (2019):

- Digital skills are essential to the future workforce in Africa, with basic skills most critical.
- Nearly 65 per cent of individuals recruited for jobs at the African companies surveyed require at least a basic level of digital skills.
- A demand–supply gap exists across all digital skill levels but intermediate skills are of most concern in the region.
- The share of employees needing more advanced digital skills will likely increase as sectors become more digitally enabled.

- By 2030, over 200 million jobs in Africa will require digital skills, which will result in almost 600 million training opportunities.
- Potential business-to-business and business-to government opportunities in sub-Saharan Africa will encompass about 625 million people who require digital skills by 2030 and result in nearly USD 120 billion in revenue. Business-to-consumer opportunities will comprise about 25 million people in need of digital skills through 2030 and USD 11 billion in revenue.

Results from Wiley Education Services and Future Workplace (2019): Closing the skills gap 2019:[9]

- 64 per cent of employers believe their organization has a skills gap (compared with 52 per cent the year before).
- The three most in-demand hard skills are strategic thinking and analytical skills (48 per cent), computer skills (46 per cent) and project management skills (32 per cent).
- The three most in-demand college majors are computers and IT (44 per cent of organizations). business (42 per cent), and science, technology, engineering and mathematics (STEM) (32 cent).
- Accelerating technology and a lack of qualified candidates are the greatest barriers to filling open roles.

More recently, in the United States, the National Skills Coalition released fact sheets that assessed the condition of American workers' digital skills across five major industry sectors — health and social work, manufacturing, construction, retail and hospitality. According to their findings:[10]

- There are skills gap across all the five industry sectors analysed.
- The COVID-19 pandemic revealed a need for workers in all industries to have strong digital skills.
- Approximately one in three American workers has limited or no digital skills and there are significant variations among the five industry sectors.
- One third (33 per cent) of workers in the health and social work sector, for example, have limited or no digital skills.
- As the pandemic has shown, these skills are critically important in providing telehealth services, recording patient data to share with fellow providers in disparate locations, and monitoring the well-being of elders, rural patients and others who may be isolated.

The above-cited studies confirm the pressing need to address the global digital skills gap. As a result of the pandemic, demand for digitally skilled workers will increase with the accelerated move towards a digital transition across all industry sectors. While many jobs will be lost due to the economic crisis following the pandemic, new jobs will emerge in the field of digital technologies and others will require digital skills ranging from basic to advanced levels.

## Digital skills and the digital divide

Digital skills are not only critical to finding or keeping jobs. They are also critical to closing the digital divide. According to ITU data, in 2019, 46 per cent of the population worldwide was still not using the Internet, with slowing growth rates compared to earlier years because some parts of the world are reaching saturation.[11] In developing countries, 53 per cent of the population is offline, and in least developed countries almost 80 per cent of the population is not using the Internet. This stands in stark contrast to the highly digitized economies and societies in middle- and higher-income countries.

It is often wrongly assumed that the lack of Internet services in remote areas is the main reason for the gap in Internet use. The large majority of the global population (93 per cent) lives in an area that is covered by at least a 3G mobile signal/service (and 82 per cent covered by a 4G signal), based on data provided by national telecom operators. Hence there are other reasons why many people do not use the Internet. These include quality of the connection, cost of the data packages, cost of devices to access the Internet, and lack of education and skills.

Indeed, one of the main barriers to Internet uptake is the lack of capacity and skills of people to use the Internet and take advantage of what it offers.[12] Data collected in developing countries through national representative household surveys and compiled by ITU,[13] as well as through After Access surveys,[14] provide revealing insights in this regard: when people are asked why they are not using the Internet, around 65 per cent of the answers are linked to education and skills (e.g. “don’t know what the Internet is”, “don’t know how to use it”).

Even in more advanced countries, 60 per cent of the population lack standard digital skills.

There is a strong correlation between people's levels of education and Internet use. In many low-income countries education levels are low, resulting in low levels of skills in terms of reading, writing, languages, analytical thinking and others. The gap between people having access to Internet and not using it is largest in the least developed countries (79 per cent 3G service coverage compared with 20 per cent Internet use in 2019). The gender Internet user gap is also the largest in these countries and it is often girls and women who are also less educated and digitally illiterate.

In other words, the digital divide is increasingly becoming a reflection of existing skills and education divides among populations. It is usually the more marginalized groups, including women and girls, who are less skilled and educated. These groups are also being hit hardest by the pandemic and the unfolding economic crisis caused by it. Education, digital skills, gender and the digital divide are very closely interrelated. Any policy measures in these fields must therefore first and foremost address all these aspects concurrently. If not, there is a real risk of widening the digital divide, particularly the digital gender divide.

## Overview of the publication

This edition of "Digital Skills *Insights*" covers eight articles which offer a rich discussion of recent research and development projects carried out on the topics mentioned above. They can be grouped into four broad themes: covering the demand and supply of skills from a broader analytical perspective; new jobs created and the associated skills required; new skills required related to data literacy and online information; and linking the digital gender divide, capacity development and digital opportunities.

### Skills demand and supply

The first two articles take a broader perspective on the type of digital skills that are needed in the digital economy and future labour market, and how they can be obtained.

The article by **Hakima Chaouchi and Thomas Bourgeau** poses the provocative question of whether everyone needs to learn programming in order to succeed in getting a job in the digital economy. To answer the question, the authors look at the pace of digitization across different industries and their adoption of different digital applications. This will drive the impact on the respective industry and on the digital skills of their workforce. Industries that have already adopted core digital technologies are more likely to adopt new AI tools and solutions, thus requiring new digital skills in their workforce.

The authors distinguish between users and creators of digital technologies and argue that digital skills are necessary for both, albeit at different levels. For example, basic and intermediate digital skills will be increasingly required in non-tech jobs (users of technologies) whereas more advanced digital skills will become necessary in jobs that build and maintain the digital tools required in different industries.

Their research finds that smaller proportions of workers will need advanced digital skills but these will be critical workforce members. These jobs include cybersecurity, AI and creative digital services and will require advanced programming and STEM skills. Jobs requiring intermediate digital skills along with basic programming and coding proficiency are likely to be outsourced to online workers in emerging economies. Finally, jobs in the basic digital skills category, which will be abundant across most industries, will require skills in configuring, using and interacting with digital tools including software, robots, Internet of Things devices, voice controllers and automation servers.

The authors conclude that all jobs that require advanced digital tools and solutions also require programming skills. Such jobs also require workers that can master computer programming logic even if they do not have programming skills themselves. Most future jobs across various industries will require digitally skilled workers to configure, interact with and use digital tools. No advanced programming skills will be needed for these jobs but a set of other (basic and intermediate) digital skills will be.

The article by **Elyn L. Solano-Charris, Carolina Velásquez-Mora and Estephanie Silva-Avellaneda** maps digital skills with future jobs and identifies the main skills denoted in the digital economy, based on bibliographical analysis. The authors found a huge increase in the number of studies related to digital skills and jobs over the past four years. According to their literature research, there is agreement that digitization will continue to transform skills requirements for employees in the foreseeable future. The skills and competencies most needed in the digital economy include technical, managerial, personal and social skills. Such skills will support the lifelong learning of individuals and their ability to adapt to workplaces and future disruption, and succeed in a digital economy.

The authors recommend that education and training institutions adapt to the challenges of automation and digitization with a highly practical orientation and accelerated changes in vocational training to respond to evolving occupational profiles and skills needs. After initial training, further training and retraining will be necessary since employees will have to engage in lifelong learning if they are to be capable of responding to changes in skills requirements triggered by automation and digitization. To make this happen, governments, businesses, educational systems and society need to work together to support a dynamic workforce and constantly redefine the skills demanded by future jobs.

## New jobs and skills required

The next two articles focus on specific digital technologies and their impact on skills and employment, looking at very different types of skill sets: those related to AI automation and those related to transportation platforms as part of the gig economy.

In his article, **Lav Varshney** examines empirical results and predictions of AI automation's impact on employment. While there is considerable debate on which jobs may be eliminated due to AI, the empirical results are challenging and vary widely. Such differences are largely attributed to whether the analysis is performed at the level of broad occupations – which leads to higher estimates – or at the level of decomposed tasks within occupations, which results in lower estimates. The author highlights that predictions are difficult not only due to a paucity of detailed data and models of job reskilling and migration, but also due to the fundamental unpredictability of developments in AI abilities.

The author then looks at the downstream impacts of the technological shock of AI, such as shifting to new jobs via skill acquisition. This will imply providing training to enable people to move into new job sectors and has been a standard policy response to the AI revolution. He finds that rural areas are less robust to automation than metropolitan areas because occupations are more concentrated in rural areas so the absorption of displaced workers is not spread out. In this sense, larger cities may be more resilient to automation by having broader absorptive capacity.

These empirical findings and model-based predictions can be used by policy-makers to develop appropriate policy responses: for example, to determine which kinds of digital reskilling programmes may be more effective and which geographical areas may benefit from them the most.

At the other end of the digital technology spectrum, the article by **Hilda Mwakatumbula and Goodiel Moshi** examines the emerging gig economy in Africa and the digital skills that are required for workers to participate in it. Their particular focus is on transportation platforms such as Uber.

The authors argue that this is of high interest in the African context, given that Africa is home to the youngest population in the world and that African youth face challenges integrating with the global economy, including pervasive unemployment due to low education levels. In sub-Saharan Africa, digital technologies have the potential to create new career opportunities but digital illiteracy excludes a sizeable population in the region from adapting to new technologies, limiting their potential participation in the digital economy. Thus, building human capital, specifically in digital skills, is critical for the region to leverage the benefits of the digital economy.

The article analyses the essential digital skills required to participate in the digital labour market using the Uber gig digital market platform in Tanzania as a case study. The authors find that there are a number of essential digital skills required for online drivers, including: smartphone technical operations, the ability to manage information, the ability to communicate online, critical thinking and problem-solving, online safety and e-payment/banking. On the basis of interviews with Uber drivers, they highlight the need to improve the level of digital skills among youth in Tanzania. The interviewees confirmed that digital skills training is likely to unlock employment opportunities for youth and reduce critical entry barriers to the workforce, as the level of digital skills needed to participate in gig labour markets is low.

The authors conclude that to ensure inclusiveness in the workforce participating in the digital gig market in Tanzania, it is essential to establish the necessary foundations to be able to leverage opportunities in the digital platform economy. That includes first building human capital readiness, and second creating a conducive environment to facilitate innovation and job creation.

### New risks require new skills: Online information and data literacy

How to manage, access, interpret and use data and information online requires specific skill sets. An increasingly important skill that citizens need to learn is linked to the digital literacy needed to assess the quality of information that is circulated and being able to critically analyse it.

The article by **Alicja Pawluczuk, Simeon J. Yates, Elinor Carmi, Eleanor Lockley and Bridgette Wessels** addresses the emerging issue of the quality of online information and explores the types of skills needed to empower citizens to better understand and engage with it. They argue that many citizens have a limited understanding about the data they share online. This lack of data literacy opens citizens up to personal, social and financial risks and limits their ability to operate as fully informed active citizens in a growing digital society.

On the basis of a nationally representative survey of British citizens, the authors develop a new data literacy framework called 'Data Citizenship' that focuses on three domains: Data Thinking (citizens' critical understanding of data and critical thinking abilities when dealing with data in their everyday lives), Data Doing (people's everyday engagements with data; a set of skills essential for conscious and informed digital participation in the data society) and Data Participation (people's proactive engagement with the data society and their networks of literacy).

Their findings indicate that those with higher levels of Data Thinking are also more proactive in Data Doing and seem to take more active steps to fact-check. Citizens who present themselves as confident 'data thinkers' and 'data doers' are more likely to be active data participants. Some of the lowest scores in Data Participation behaviours were noted among social and media users. Members of this group seem to be among some of the most passive data citizens, most of whom are aged 16–24 years old, from a lower economic class and lacking higher education. The authors observe that these findings de-mystify the assumption that young people born in the digital era will naturally adopt digital literacy. Contrary to this, the authors' research reveals that age, education and socio-economic status are critical to people's understanding, doing and participating in the digital society and thus their management of information.

### Gender gap, skills and employment

This year's edition features three articles that focus on the topic of gender and digital skills, covering aspects related to the digital gender divide and the gender skills gap, and examples of successful programmes to address those issues.

The article by **Ingrid Brudvig, Nanjira Sambuli and Dhanaraj Thakur** looks at why bridging the digital gender gap relies on gender-responsive ICT policy and argues that the digital capabilities of policy-makers need to be strengthened for them to better understand the barriers to Internet access women face, and to equip them with the tools to promote more gender-inclusive public policy.

The paper argues that sex-disaggregated data are critical to monitoring the extent of the gender gap and to informing gender-responsive technology policy-making. They also stress that any policy or project to get more people online will only reinforce digital inequalities unless it specifically targets the gender gap. While a few countries have taken some steps in their policies to address the gap in access and use, these are insufficient and much work remains to be done. In addition to developing gender-responsive policies, it is critical that women are included in the actual policy-making process. The paper then assesses how the digital skills development approach impacts perceptions of gender equality in ICT policy formulation. They present the example of a programme (called

#eSkills4PolicyMakers) to share knowledge and build skills to help governments create policies that specifically target marginalized groups.

To conclude, the authors recommend that developing gender-responsive ICT policies starts with enhancing the digital skills of policy-makers. The process of educating policy-makers on gender equality in ICT policy formulation also requires collecting relevant sex-disaggregated data and evidence to make the case and inform policy, as well as develop gender-responsive ICT policy based on participatory processes with women included in the decision-making.

The article by **Florianne C.J. Verkroost, Ridhi Kashyap, Kiran Garimella, Ingmar Weber and Emilio Zagheni** analyses gender gaps in the IT industry based on data from the advertising platform of LinkedIn, which the authors use to estimate the supply side of these industries and identify gender gaps across countries. They disaggregate the IT industry into subdomains comprised of computer hardware, computer networking, semiconductors and wireless, Internet, telecommunications, IT and services, and computer software.

Unsurprisingly, the authors find that in most countries there are more men than women in the IT industry. While there are generally twice as many men as women in most of the Americas, Europe, Asia and Oceania, there is even more gender inequality in IT industries in Africa, especially in the northern and central regions. Regions with high and upper-middle income countries have more gender egalitarian IT sectors than their counterparts with low and low-middle income countries. While women are underrepresented in all IT industries considered, there is nevertheless some variation. Looking at specific subdomains of the IT industry, their research finds that while there are about four times more men than women in computer hardware, networking, semiconductors and wireless, there are about twice as many men as women in Internet, telecommunications, IT and services, and software.

Further data analysis shows that gender-specific development factors matter more than economic development in explaining variations in IT gender gaps. On average, gender inequality in IT is lower in countries where women are more equal to men in terms of educational and economic opportunities. This indicates that economic development may affect men and women differently in the professionally arena, and that developmental efforts that do not specifically address gender may not be enough in themselves to reduce professional gender inequalities in the IT sector.

The final article, by **Babatunde Okunoye,** examines the digital gender divide in Africa and explores the approach that Paradigm Initiative (PIN) – a social enterprise based in Nigeria working on digital inclusion and digital rights – has adopted to bridge this divide and build digital skills capacity through its programme offices in two cities in Nigeria.

The author first provides insights into the digital gender divide in Africa and other developing regions based on existing data and research which has revealed that women are less likely to access the Internet, and even if online they are less likely to use the Internet to increase their income or participate in public life. Even though young girls often express interest in STEM fields and computer science, few continue to pursue computer science degrees and women are notoriously underrepresented in the technology industry and IT jobs. The author argues that factors other than lack of interest in technology careers are to blame for the poor representation of women in these careers, including the absence of suitable role models, lack of representation in trainers in digital skills capacity development institutions, and the influence of authority figures.

In this context, PIN has devised programmes that aim to overcome these factors, including its digital skills capacity-building programme called Life Skills, ICTs, Financial Literacy and Entrepreneurship (LIFE) training. The author reports that at the inception of the programme in 2007, boys always outnumbered girls in enrolment and completion of classes. PIN therefore instituted policies to tackle this by directly confronting the factors (mentioned above) which hindered girls' enrolment in the programme. The implementation of these policies resulted in classes with a near-equal number of girls and boys, and in some instances with girls even outnumbering boys.

The article finds that one of the most important policies that contributed to the increased participation of women and girls was the mandatory representation of women in the programme design. In addition, PIN staff hold weekly meetings with parents and community leaders in their homes and offices to explain details of their work and approach, clarifying that digital skills will improve the economic prospects of their female children. These meetings have significantly improved women's participation in and completion of the programmes. Finally, the author stresses the importance of career role models. LIFE has embedded mentoring sessions where young women can interact with women who have succeeded in careers in technology and be inspired by their example.

## Conclusion

The articles included in this edition of "Digital Skills *Insights*" feature a number of common themes around the topic of digital skills. First, they stress the importance of strengthening and enhancing skills to be successful in the digital economy. Such skills range from basic to advanced digital skills. Second, they highlight the interrelationships that exist between digital development, skills, employment and jobs, and emphasize that none of these should be addressed in isolation but be part of a holistic approach. Third, they illustrate the importance of collaboration and engagement of different stakeholders in the strengthening and building of digital skills among citizens – policy-makers, educational institutions, industry, development practitioners and local communities. Finally, all articles provide concrete suggestions and recommendations on how some of those challenges can be addressed.

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## Endnotes

[1] https://en.unesco.org/news/reopening-schools-when-where-and-how

[3] In the United States, it has been estimated that 37 per cent of jobs can be performed entirely from home. https://www.bls.gov/opub/mlr/2020/beyond-bls/pdf/the-number-of-people-who-can-telework-is-higher-than-was-estimated.pdf; and that during COVID-19 around half of workers worked from home.

[3] https://www.brookings.edu/blog/up-front/2020/04/06/telecommuting-will-likely-continue-long-after-the-pandemic/

[4] For example, a recent survey in Singapore found that 80 per cent of employees would like to continue working from home after the pandemic. https://www.straitstimes.com/business/economy/most-employees-keen-to-continue-working-from-home-after-circuit-breaker-survey?utm_medium=Social&utm_campaign=STFB&utm_source=Facebook#Echobox=1588152587;

[4] Google announced to let their employees work from home until at least summer 2021. See https://edition.cnn.com/2020/07/27/tech/google-work-from-home-extension/index.html; similarly, Facebook work from home is indefinite, see https://www.foxbusiness.com/technology/facebook-work-home-indefinite-coronavirus

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# Will all jobs require programming skills in the growing digital society?

*By Hakima Chaouchi & Thomas Bourgeau*

## Introduction

Digital technologies have developed rapidly in recent decades, changing how we access information as well as human interaction and communication. Most importantly, however, they have also transformed various jobs, impacting the global economy and society. Computer science is a broad discipline requiring mastery of different programming languages and their execution to provide the desired digital functionality across various domains that are constantly evolving. Specific programming languages and design algorithms require different skills, such as the ability to develop digital tools for various industries; to develop hardware and software to run Internet protocols, cloud architectures, websites and mobile applications; or to run the automatic navigation systems of self-driving cars or farms' sensor networks. The skills required to develop mathematical algorithms that shape decision-making in different industries or to build and configure robots and other human-machine interfaces are also in demand.

In this article we discuss the digital skills shortage in the workforce and the latter's evolution with new technologies, as well as the adaptation of education to match emerging jobs. We argue that digital skills are necessary for both users and creators of digital technologies and introduce the different levels of digital skills related to the use and creation of digital solutions. We predict that basic and intermediate digital skills will be increasingly required in non-tech jobs because industrial digitization will require mastery of digital technologies, and that more advanced digital skills will become necessary in jobs that are in charge of building and maintaining the new generations of digital tools required in different industries.

The challenges are clearly to establish the necessary learning content and methods to keep pace with the evolution of digital technologies, to define the suitable learning age for which type of digital knowledge, and to continuously maintain and adapt this learning to meet the demands of the digital society and the digital economy. Education systems worldwide have sought the optimal approach to introducing digital learning in terms of appropriate age and methodology (Resnick et al., 1988; Resnick, 1993). It is crucial to determine precisely what should be taught at each stage of one's curriculum to ensure digital competencies for jobs requiring digital skills. For that, it is important to have the most accurate forecasts of jobs requiring digital skills, and each industry must proactively align its plans for digitally upskilling its workforce with its business objectives. The education system should also provide the needed digital learning to new and active workers.

While programming languages are part of the digital skills set, does it necessarily follow that all jobs require programming proficiency? Programming languages are mandatory for programmers who develop software, and knowledge of certain programming languages is also desirable for non-programming jobs that use digital solutions whose functionalities must be adapted. However, programming languages are often unnecessary for other jobs that require other digital skills and use tools that require no adaptation. Moreover, software development will inevitably lead to a new generation of languages with simplified syntax and coding to facilitate swift and easy learning. Meanwhile, programmers must learn to code using several programming languages even if the languages change quickly, as this fosters competency in the mastery of new languages.

The remainder of the paper presents the concepts and terminology behind digital skills in the second section, followed by an analysis of the impact of the fast growth of digital tools and solutions on jobs evolution in different tech or non-tech industries in the third section. The fourth section presents digital skills acquisition approaches, and in the last section we discuss the impact on human thinking of digital knowledge, particularly artificial intelligence (AI). This is about a post-AI computational thinking concept that goes beyond the digital skills needed in evolving jobs, and concerns the human thinking that is to be complemented with advanced mathematics and AI.

## Concepts and terminology

We define digital skills as a set of technological abilities that may be fully or partially acquired before entering the workforce. Some digital skills are required to use and interact with technology in order to fulfil specific tasks, while others are required to design, create and maintain tools and solutions for different industries. Different skills create different categories of digital users and job profiles.

Table 2.1 presents several terms and definitions concerning educational literacies and specific digital skills. The basic literacy skills – the 'three Rs': reading, writing, and arithmetic – function as standard indicators in education. Algorithmic literacy is promoted by some digital advocates as mandatory in today's digital society and counted by some as a fourth 'R'. We propose three levels of digital skills – basic, intermediate, and advanced – as defined in various studies (e.g. International Telecommunication Union [ITU], 2018) and introduce the emerging human-based computation skills that form a new paradigm for solving complex problems using high-performance machine computing combined with human thought.

## Impact of the digital industry on jobs evolution

Digitization in various industries transforms the workplace to ensure effective tasking, business and field resources optimization, high competitiveness, greater interaction and inclusion between workers,J' fast and efficient responses to customers, innovative services and economic growth.

The pace of digitization is not the same for each industry, as Figure 2.1 illustrates. This is for several reasons. A company's culture and readiness for digitization, the lack of available specific digital solutions for certain industries, the governance framework, and customers' willingness to adopt and use digital solutions to access services all impact the pace at which digitization occurs. The availability of mature digital technologies makes it possible for almost all industries to wholly or partially adopt digital processes and to move into the digital economy. This affects the workforce in terms of skills availability, which also affects industries' digital transformation.

The evolution of and demand for digital skills follow the pace of industries' digitization and the digital technologies and solutions that appear following the digital technologies evolution phases depicted in Figure 2.1. These are the pre-Internet and post-Internet phases, where digital services in all industries have followed the evolution of computer science and telecommunication technologies and architectures. In Figure 2.1, examples 1 and 2 on the X axis show digital technologies in the pre-Internet phase; these are applications and software running locally with no connected remote server because Internet technology was not yet invented. Later, when Internet was invented and standardized, it first offered fixed access to different digital services in different industries. Then wireless and mobile access to services with high quality of service also became possible, followed by wireless and mobile Internet.

The post-Internet phase has had several technological evolutions since the first Internet Engineering Task Force, with fixed access and distributed servers running inside the company buildings of each industry: in Figure 2.1 this is named the pre-cloud phase. Then came cloud-based architectures where servers and data were located outside company buildings: there are two phases here, named post-cloud and pre-AI. These were followed by IoT technologies, dense connectivity, robotics and cyber physical systems, and AI algorithms to automate industry processes and activities: these are named the post-AI and pre-quantum phases. Finally came high-performance computing with quantum technologies, named the post-quantum phase.

Table 2.1. Education literacies and digital skills-related terms

| Skills | Terms | Definition |
|---|---|---|
| The 'three Rs' | Reading | The basis of traditional literacy that focuses on reading human languages |
| | Writing | The ability to write a human language |
| | Arithmetic | Numeracy, with the ability to enumerate and count |
| | | |
| Algorithmic competencies (named algorithmic literacy or the 'fourth R' by certain digital advocates) | Digital literacy | The set of digital fundamentals required to interact with, configure, use and enhance digital tools. They also provide the basic digital knowledge needed in the digital economy. As described by Csernoch and Biró (2015), digital literacy allows humans to understand the machine logic used to execute different tasks and actions. Several competencies, such as programming literacy, must be acquired in the context of digital literacy. The term 'programming literacy' is sometimes used to denote the ability to use computer programming languages.<br>Recently, data literacy was introduced as the ability to manage, analyse, visualize and derive meaningful information from data. This trend is emerging due to the explosion of machine learning and big data demands in every sector. |
| | Computational literacy | The ability to formulate and solve problems through computational steps and algorithm representation. It combines knowledge from various disciplines including science, technology, engineering and math. |
| | | |
| Digital skills are divided into three levels following the ITU Digital Skills Toolkit (2018). The content of each level is specified following our vision of introducing basic and intermediate digital skills for tech and non-tech jobs, and offering advanced digital skills for digital solutions developers. | Basic digital skills | Fosters competency in interaction with basic digital tools. When these tools are based on mobile and smartphone devices, these skills are also referred to as mobile skills.<br>Basic skills cover the hardware and software know-how required to use various technological assets (computers, smartphones, software (word processors, applications)), online operations (Internet, search engines, social networks, e-commerce, privacy), and communication media (cellular and Internet protocol networks). |
| | Intermediate digital skills | Ability to configure digital tools to produce and consume digital content or enhance digital tools through basic programming skills.<br>Intermediate skills can also benefit from basic knowledge of programming language, such as spreadsheet manipulation through Visual Basic macro programming or front-end web design that is HTML- and JavaScript-dependent, or other languages that are specific to particular domains (accounting, enterprise resource planning, etc.). |
| | Advanced digital skills | Enhanced knowledge acquired through specific curriculum aspects to improve technological proficiency, programming skills and advanced aspects of specific digital branches (advanced programming, machine learning, Internet of things (IoT), networking, engineering, hardware design, etc.). This knowledge requires intermediate digital skills and is open to a wide range of programming languages, from standard languages used in the industry such as c/c++, Java and Python, to more specific languages such as OCaml, NodeJS, etc.<br>Advanced skills are generally taught through specific curricula in higher education institutions (HEIs) but they can also be acquired during a professional career with workforce upskilling training. Programming literacy is required for advanced skills as the objectives lie beyond simple or intermediate technology use, involving the design and programming of new digital tools and features.<br>Examples of advanced digital skills include science, technology, engineering and mathematics (STEM) and social, mobility, analytics and cloud (SMAC) |
| | | |

Table 2.1. Education literacies and digital skills-related terms (continued)

| Skills | Terms | Definition |
| --- | --- | --- |
| Human-based computation skills | Human-based computation literacy | This is a new paradigm that goes beyond digital skills in computer science and builds new models whereby machines will outsource certain tasks to humans, optimizing the abilities and costs of both humans and machines. |
| | Computation-based maths | A new paradigm introduced by Wolfram (2020) to boost mathematical problem resolution and promise the resolution of existing and new complex problems. Computational thinking is also used to formulate and solve problems through computational steps and algorithm representation. |

Source: Authors' own 2020, unpublished.

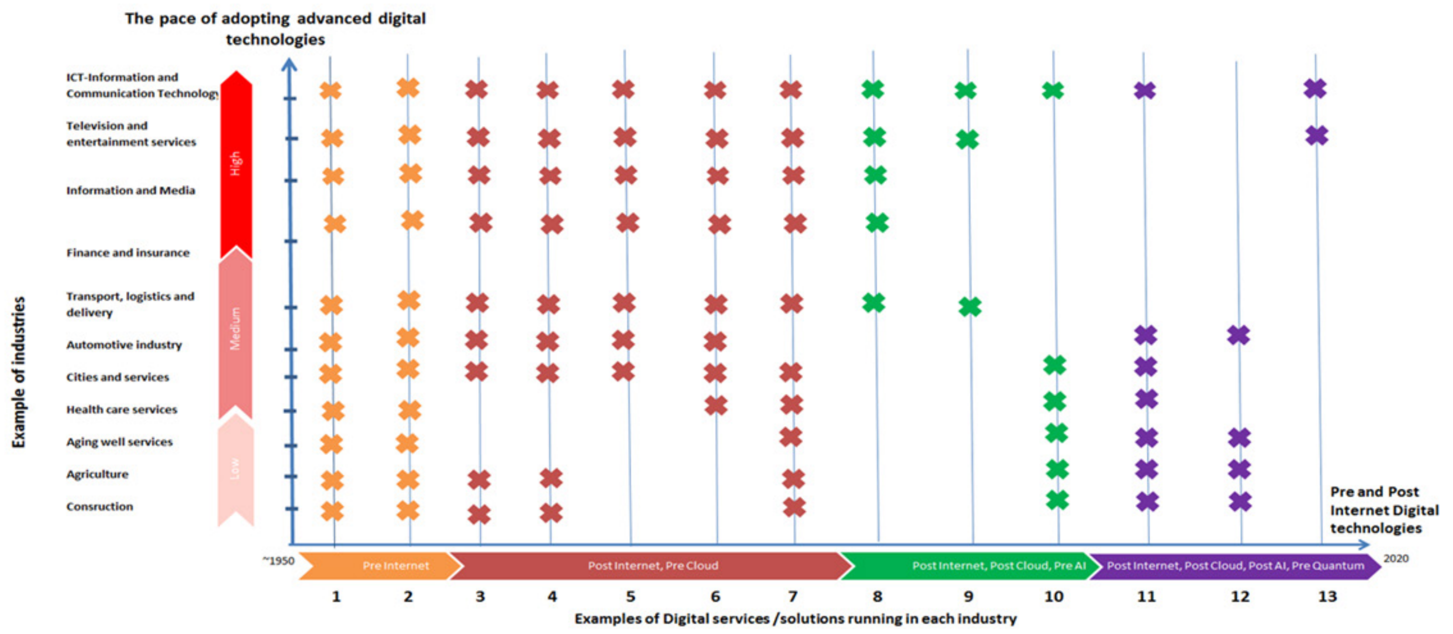
The pace of industries' digitization as depicted in the Y axis of Figure 2.1 may be low, medium or high depending on the digital transformation of all or part of the activities of these industries. For instance, information and communication technology (ICT) and services has the highest digitization pace because all the activities are digital and it is the industry that creates and maintains digital technologies and solutions for all other industries. In Figure 2.1 we also provide examples of other industries such as television and entertainment services. Information and media, finance and insurance have a high digitization pace compared to transport, logistics and delivery, the automotive industry, cities and services. The pace of digitization in these industries is medium because certain activities in those industries are still manual. Other examples of industries such as healthcare services, ageing well services, agriculture and construction have a low pace of digitization for a variety of reasons. In some cases the activities are highly manual and only recently have robotics, IoT and AI digital technologies started to become mature enough to be combined and create automatic services. In other cases regulation is slowing down digitization, as in healthcare or ageing well services, where even if digital technologies are available, they cannot be deployed and used without control and regulation.

Note also that the pace of digitization of industries as depicted in Figure 2.1 follows a strategic set of business objectives with innovative digital-based services built on both mature and available digital technologies and solutions, and the customer's readiness to accept technology. Figure 2.1 shows some examples of industries with a low, medium or high pace of digitization where the adopted digital technologies described earlier might differ, following these metrics:

- Local versus remote execution of software and applications: Computer science initially started with digital services to run information systems management in different industries, with all the services running in servers located within the company. With the maturity of cloud technologies, these services slowly migrated outside of companies to run remotely in cloud servers. Examples in Figure 2.1 are related to 1 and 2 for local services and then 3, 4, 8 and 9.
- Fixed versus wireless and mobile access to digital services: Internet had a huge evolution from its early age when digital services were accessible via fixed networks using web interfaces, to the wireless and cellular networks era where most digital services are accessible via wireless and mobile networks using wireless access and web-based mobile applications. Examples in Figure 2.1 relate to 6 and 7.
- Human versus machine/AI-based services: High digitization of different jobs by adding the most mature digital technologies such as IoT, robotics and cyber physical systems to acquire data and then process them with AI algorithms and run automatic decisions. Examples in Figure 2.1 are related to 10, 11, 12 and 13.
- Traditional versus high-performance computing: Quantum and post-quantum computers will allow new categories of digital services that require very high computation capacities. Examples in Figure 2.1 are 11 and above.

Digitization supports classic industries, as shown in Figure 2.1, but it also enables the creation of

Figure 2.1. Examples of industries’ digitization pace and types of adopted digital tools/solutions pre- and post-Internet




| Legend: Examples of digital technologies / tools / solutions | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Basic software and applications running locally | Advanced software and applications running locally | Basic software and applications running remotely via Internet | Advanced software and applications running remotely via Internet | Advanced ICT services integration | Digital Internet services, wired access (web-based access) | Digital Internet services, wireless and mobile access | Advanced ICT deployment and maintenance services (cloud, cybersecurity, Internet, SDN...) | Deployment and management of connected Internet nodes | Deployment and management of IoT devices (sensors, actuators) | Deployment of AI and data analytics tools | Advanced digital cyber physical products (connected cars, drones, manufacturing robots...) | Advanced ICT services (tactile Internet, virtual reality, holograms...) |

Source: Authors’ own 2020, unpublished.

new and innovative services that compete with some established industries. For instance, with the sharing economy paradigm, new services have emerged (Perini et al., 2013) – such as Uber in the transport industry or Airbnb in the tourism industry – that take advantage of the high connectivity of mobile Internet technology, smartphones' easy access to web applications and the availability of smart algorithms to connect service producers with consumers in real time. These new digital services offer customers enhanced service experiences that persuade them away from the classic equivalent options. Other digital services, such as Netflix, have emerged in the multimedia and entertainment industries. Thanks to the connectivity between devices and applications as well as AI and efficient prediction algorithms technologies, these services collect consumers' preference data to adapt their content and maintain consumer satisfaction. The transport industry is also exploring new self-driving vehicle technologies to create new ways of accessing transport in urban and rural areas thanks to cyber physical systems, 5G mobile Internet high connectivity, and efficient AI navigation systems technologies.

The digital skills required in this new digital economy must be taught to minimize the risk of a digital skills gap (Strack et al., 2019). Various forecasts in different reports (e.g. Manyika et al., 2017) predict the creation of several million new jobs worldwide with these emerging technologies, as well as the displacement of existing roles. Those forecasts should be carefully analysed by each industry, as recommended by Gartner Research (2019), to build a strategic skills training plan suitable for the relevant workforce. This plan should begin by identifying the requisite digital skills for the corresponding industry before determining its adoption pace.

*The future of jobs report 2018* (World Economic Forum, 2018) shows a set of digital technologies that might be adopted by different surveyed companies in different industries. Those technologies are, as described in Figure 2.1, either related to software applications running locally on computers and/or smart tablets, or running remotely over cloud services. Those technologies are also related to the manufacturing and deployment of new AI algorithms for automation, advanced manufacturing robots, connected devices that are either running in the information and communication technology industry or in vertical industries such as health, agriculture, construction, finance, etc.

They are mainly based on Internet connectivity devices, wireless and mobile networks, smartphones and tactile Internet, applications and software programming, web applications and web services, robotics and virtual and augmented reality, mobile applications, cloud services, cybersecurity systems, IoT with multiple sensors and gateways, cyber physical systems and robotics, human–machine interfaces, data, and AI algorithms and solutions.

Digital technology maturity and industries' readiness will define the digitization pace followed by each industry and establish the pace at which the relevant workforces transform and identify the required digital skills. As described in Atos (2020), adoption in the business evolution of each industry of a range of digital technologies – such as software development, open sources, open hardware, wireless and wired connectivity to Internet, cloud technologies, cyber physical systems, IoT, AI, robotics, self-driving cars and others – will drive a low or a high impact on the respective industries and consequently on the digital skills of their workforce.

After the requisite digital technologies have been identified and the pace of their adoption in the relevant industries determined, strategic digital skilling plans will define the different job profiles to be adapted, rendered obsolete, or created. New jobs include those based on the so-called STEM skills,[1] as well as those related to cloud native skills encompassed by SMAC / SMAC plus security / SMAC plus automation.

Other roles such as data analysts, social media community managers, data cleaners in so-called data factories, etc. will be increasingly relevant in various industries. Digital skills gaps will be highly related to new jobs needed to support digital transformation in different industries, such as data scientists, AI specialists and automation specialists. Finally, the displacement of some existing jobs (e.g. factory and assembly roles or secretarial positions) as a result of automation is inevitable and must be carefully considered in strategic digital skills training plans.

Figure 2.2. Examples of programming languages


Source: Authors' own 2020, unpublished

The manufacturing industry in particular is predicted to cull numerous jobs due to direct automation from robotics. However, some manufacturers, such as Toyota (Bork, 2018), are reinstating humans in their production lines. Therefore, the automation process will pursue certain performance objectives whereby humans and machines will work together. As such, co-work between humans and machines is an aspect of such industries' strategic plans. Industry 4.0 is the paradigm that plans to reshape the manufacturing industry, in which advanced digital skills – including connected robotics, cloud and cloud edge, industrial IoT, and AI – will be required to develop new services and new digital processes to facilitate the optimization of manufacturing resources. Industry 4.0 will quickly encounter a digital skills gap due to the maturity of AI-based digital solutions. Of course, AI will also be adopted in other industries such as energy and utilities, health care, retail, finance, travel and hospitality, to name a few. The question which remains unclear is how and at what pace it will affect existing jobs in those industries.

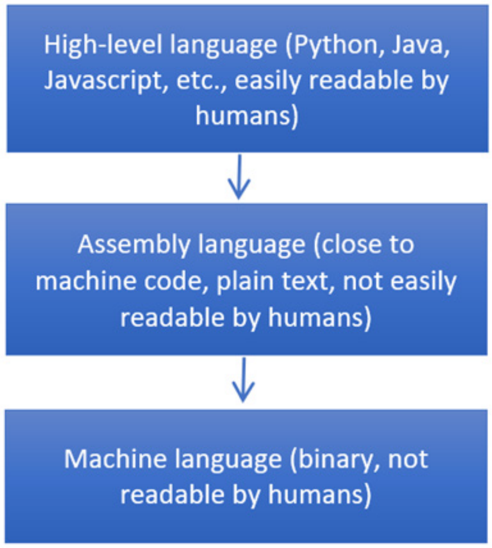
Several studies have shown that industries that have already adopted core digital technologies are more likely to adopt new AI tools and solutions, thus requiring new digital skills in their workforce. Different AI-related technologies are under development and quickly adopted by industries that are transforming their services using these new digital solutions. Some examples are virtual agents, natural language generation and processing, machine learning, decision-making, robotics process generation and speech recognition. *Artificial intelligence: Why a digital base is critical* (Bughin & van Zeebroeck, 2018) shows the probability of the adoption of AI technologies by surveying companies from different industries willing to adopt them.

Industries are aware that these well-identified digital skills may require different learning strategies and implementation plans that should also address the swift evolution of digital tools and services; for example, jobs requiring programming language skills must monitor the evolution of programming languages, as illustrated in Figure 2.2 below.[2]

Jobs involving data-based decision-making will likely require related programming skills; for instance, a medical doctor will need to use machine learning solutions and related digital tools.

Other industries that rely on IoT devices for data acquisition should also plan for advanced digital skills evolution as IoT and AI are emerging technologies that are still growing. Atos IoT emerging technologies radar for IoT projects (Atos, 2020) shows the high evolution of IoT-related software, hardware and connectivity technologies. This IoT technology heterogeneity is somehow slowing down the predicted high adoption of IoT technologies in different industries planning for digital transformation. This regular evolution of technology requires continuous planning for upskilling in the concerned industry workforce. For instance, farmers will be equipped with devices and tools to digitally monitor their agricultural processes (European Commission, 2020). In the health industry, connected objects such as smart wearables will be deployed and new digital tools, such as more accurate medical imaging, will enhance healthcare processes, meaning that workers in these industries will become proficient in using various digital tools and processes.

Figure 2.3. High-level and hardware programming languages




Source: Authors' own 2020, unpublished

As the examples above illustrate, the digital skills gap in the emerging Industry 4.0 digital economy concerns all categories of jobs. Smaller proportions of workers will need advanced digital skills but these will be critical workforce members. These jobs include cybersecurity, AI, and creative digital services and will require advanced programming and STEM skills to create and design the necessary tools. Jobs requiring intermediate digital skills along with basic programming and coding proficiency are likely to be outsourced to online workers in emerging economies. Jobs in the basic digital skills category, which will be abundant across most industries, will require skills in configuring, using and interacting with digital tools, including software, robots, IoT devices, voice controllers and automation servers.

Based on the above discussion, the answer to the question posed in this article – Would all jobs require programming skills in the future? – is 'yes' for all jobs that require advanced digital tools and solutions. Such jobs largely encompass two categories: programming, which unquestionably must monitor the evolution of computer programming languages (see Figure 2.2), and non-programming, which does not require workers to learn programming languages' coding syntax but does require them to master computer programming logic and the high-level languages used in their respective industries.

As most digital tools and solutions require different programming skills, ranging from hardware/machine-programming languages to high-level service/application-programming languages (see Figure 2.3), different skills are required for each level, with the greatest complexity in hardware/machine programming. This defines the different categories with respect to programmers' jobs.

Programmers must acquire the skills needed to master the fundamentals behind several programming languages. These fundamentals concern the capacity to read and write programming language syntax, machine logic implementation, and code compilation and debugging. The complex requirements of such jobs include the ability to quickly learn new programming languages and master the syntaxes required to write the same program in different languages, as shown in Figure 2.4, but also to master the specific functionalities of the programming language, such as hardware systems or applications programming.

Regarding other non-programming jobs in different industries, in which intermediate and advanced digital skills require proficiency in certain high-level programming languages, it will be important to understand computer/machine logic and choose the language appropriate to the corresponding industry. For example, medical doctors will be increasingly exposed to new digital tools running patients' data analytics and machine

Figure 2.4. Example of programming languages syntax (to write ‘Hello World’ onscreen)

1- C language:

```
#include <stdio.h>

int main(void)
{
    printf("hello, world\n");
}
```

2- Cobol Language:

```
IDENTIFICATION DIVISION.
PROGRAM-ID. hello-world.
PROCEDURE DIVISION.
    DISPLAY "Hello, world!"
    .
```

3- Go language

```
package main

import "fmt"

func main() {
    fmt.Println("Hello, World")
}
```

4- Java language

```
class HelloWorldApp {
    public static void main(String[] args) {
        System.out.println("Hello World!"); // Prints the string to the
console.
    }
}
```

5- Javascript Language

```
console.log("Hello World!");
```

6- Python language

```
print("Hello World")
```

7- Mathlab Language:

```
classdef hello
    methods
        function greet(this)
            disp('Hello, World')
        end
    end
end
```

8- RUST Language

```
fn main() {
    println!("Hello, world!");
}
```

Machine Code

```
b8    21 0a 00 00   #moving "!\n" into eax
a3    0c 10 00 06   #moving eax into first memory location
b8    6f 72 6c 64   #moving "orld" into eax
a3    08 10 00 06   #moving eax into next memory location
b8    6f 2c 20 57   #moving "o, W" into eax
```

Source: Excel with business (2020).

learning solutions. It will thus be necessary for the new generation of medical doctors to acquire skills related to machine learning programming tasks, such as MATLAB. Other doctors may also collaborate with trained machine learning specialists. In any case, education systems across all disciplines are incorporating basic programming skills into their curricula, increasingly facilitated by the growth of the digital natives generation. Basic programming skills constitute the capacity to identify and programme the sequence of tasks to be executed by machines in order to produce a certain output/action. On a positive note, the programming language used in this programming logic for non-programmers will be increasingly advanced so as to be syntactically closer to human language. Advanced digital solutions are being developed to facilitate the automatic translation of high-level programming languages to machine language, thus masking the complexity of machine programming/coding for non-programmers.

Finally, industry digitization will also face policies and governance regulations that will impact the adoption of digital technologies. Selected digital solutions will have to be robust against cybersecurity threats and technical failures, thus requiring cybersecurity digital skills in the relevant industry. Technological availability, maturity, robustness against cyber threats and conformity to a well-defined governance framework will be the main orchestrators of the pace of technological adoption in different industries, thus affecting jobs evolution, followed by digital upskilling plans and implementation programmes.

## Digital skills acquisition approaches

The digital skills gap has been analysed by different firms, all converging towards the estimation that over half of all organizations are already facing it. The required core digital skills such as high expertise in cybersecurity, cloud computing, big data, programmable networks and 5G, data analytics, web and mobile app development are becoming strategic assets in each industry. High-tech firms are competing to build this high expertise internally, and maintaining a high level of knowledge in those core competencies is mandatory to survive in the high competition of the digital industry. A good example is the cloud service offers from different firms – such as Amazon AWS, Microsoft Azure, Google Cloud, OVH and Alibaba Cloud – that are innovating in different digital cloud services and counting on their internal core digital competencies to maintain quality of service and stay in the competition.

Due to this digital skills gap, a strategic workforce upskilling plan is required. As noted above, this strategic plan should be based on identification of the necessary digital technologies and their maturity, and the pace of their adoption in the industry's activities.

The identified digital technologies will establish the requisite digital skills for the workforce. Various views exist regarding how workforce skills preparation should be implemented by educational institutions, education policy-makers and workplaces, as described in the subsections that follow. Ideally, the industries expect institutions to teach the adapted digital skills before graduates enter the workforce. However, as classic education systems implement general curricula, they will only provide the literacies needed by the new generation to acquire new skills during their careers. As the digital skills gap is widening, the urgency to link industrial skills to curricula and to ensure that the majority of the digital skills are acquired prior to entering the workforce is increasing.

### a) HEIs' learning initiatives adaptation for a digitally skilled workforce

Technological evolution and the workforce skills shortage are clearly disrupting HEIs' programmes and methods. Digital technologies have already allowed HEIs to make learning content accessible online, making it possible for anyone to learn the offered course by themselves. Online learning and online degrees are flourishing, thanks to massive open online course technology. However, most companies still prefer on-campus qualifications and evaluation processes, and acknowledge online learning as additional knowledge, similar to personal learning programmes. Digital and computational skills knowledge must therefore be regularly adapted by HEIs, following industry expectations, to allow graduates to enter the workforce as scientists, engineers, managers and technicians capable of shaping and running the new digital economy with emerging AI-based tools and methods and mastering cybersecurity, cyber defence and cloud architectures across all industries.

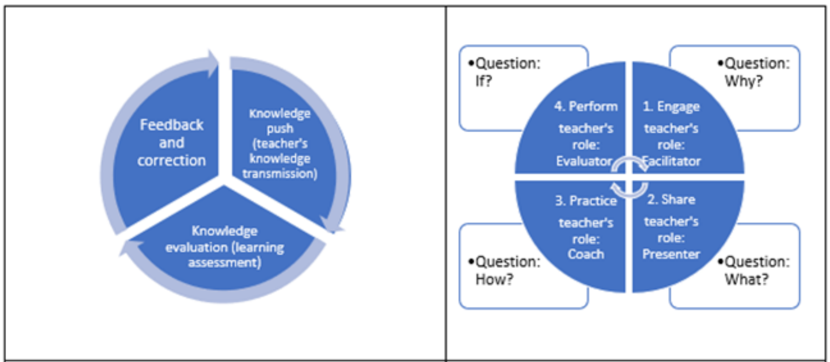
Several ongoing initiatives aim to improve education skills in line with workplace expectations. For example, the United States has implemented the Computer Science Education Act and the European Commission has launched different initiatives, including the Erasmus Knowledge Alliances and the new European Universities Initiative. Additionally, universities are adapting existing curricula to match STEM and SMAC job profiles.

### b) Corporate lifelong learning initiatives for a digitally skilled workforce

The creation of a strong corporate learning programme that adapts to the evolution of internal workforce skills may be achieved by establishing an internal continuous learning culture, but also by influencing HEIs and vocational training institutes to adapt their curricula to match the evolution of workforce skills through different partnerships. Industries are reinforcing their internal corporate lifelong learning strategies and programmes to better manage their workforce evolution and upskilling. New industrial academies and campuses are emerging online with clear learning content and programmes. Some are dedicated exclusively to internal workforce upskilling or reskilling, while others are publicly accessible with the objective of training future employees that can be recruited by the company. Some industrial academies are also creating joint programmes with universities where the expected workforce skills are promoted in their curricula. These industrial academies also support online learning because it aligns with the employment schedule.

Industrial academies have greater flexibility in experimenting with new digital tools such as learning factories or virtual reality-based classes, and new learning approaches are being trialled. Upskilling requires fast and efficient learning approaches. Various learning models have been revisited, mainly corresponding to the two approaches shown in Figure 2.5 that are, first, pedagogy (which pertains to teaching children), and second, andragogy (which pertains to teaching adults) (Knowles, 1980).[3] The latter approach promotes learning by doing and is well supported by new technological tools such as virtual reality, serious games classes or learning factories, where it has been observed that upskilling workers for specific tasks will be more efficient than classical pedagogical approaches, which involve considerable abstraction in learning.

Figure 2.5. Pedagogy and andragogy learning approaches




(a) Pedagogy passive learning model | (b) Andragogy 4MAT active learning model.

* McCarthy, B. (n.d.). *Master training design.* http://www.4mat.eu

Source: Authors' own 2020, unpublished

Various innovative education (EdTech) start-ups are piloting new approaches and tools while basing their innovations on neuroscientific findings or innovative digital learning tools and methods.[4] Finally, some industries are deploying careers coaching to narrow the digital divide in addition to generational or gendered divides (Deloitte, 2018).[5]

### c) Vocational training initiatives for digital skills workforce matching

Vocational training is responsible for educating a future workforce that will complement university-graduated employees. It usually focuses on manual skills such as baking, carpentry, plumbing, logistics and transport. With the high demand for digital and basic programming skills in the workforce, vocational institutions are already incorporating digital skills into their programmes to match workplace requirements. These include basic programming and coding competencies, human-robot interaction, voice control command systems, or virtual reality-based interactions with connected processes.

Recently, in France, the debate around introducing programming and digital knowledge learning phases in schools has resulted in several initiatives to provide students with digital learning certificates following a vocational training programme,[6] and a platform via which students and children aged 13 and over can acquire digital skills, rewarded with a digital certificate.[7]

At the international level, ITU aims to strengthen digital skills at basic, intermediate and advanced levels through a number of projects and initiatives, including the Centres of Excellence programme, the Digital Transformation Centre Initiative, and, in partnership with the International Labour Organization, through the Digital Skills campaign described in the report *Digital skills: Preparing young people for the future of work in the digital economy* ( Decent Jobs for Youth, 2017).

Other initiatives, such as the European Union DigComp (Vuorikari et al., 2016), have aimed to improve citizens' digital competencies and shape digital competency building. Similarly, the Digital Skills and Jobs Coalition initiative in the European Commission's new Skills Agenda is intended to guide the vocational training of young unemployed people and help upskill the workforce.[8]

## Beyond digital skills: Post-AI and computational thinking

Economic studies have forecast that the digital economy will continue to affect workforce evolution, and a severe digital skills gap is predicted if no digital upskilling plans are urgently established in different industries. However, digital societies emphasize that citizens must be digitally skilled to better interact with digital tools and processes, thus promoting digital literacy as a universally necessary asset for all citizens (Vuorikari et al., 2016) and the workforce in the growing digital economy. Regarding the question posed in this article – will every job involve programming skills in the growing digital society? – the answer is 'yes' for all jobs that involve advanced digital tools and solutions and 'no' for jobs that do not involve digital tools.

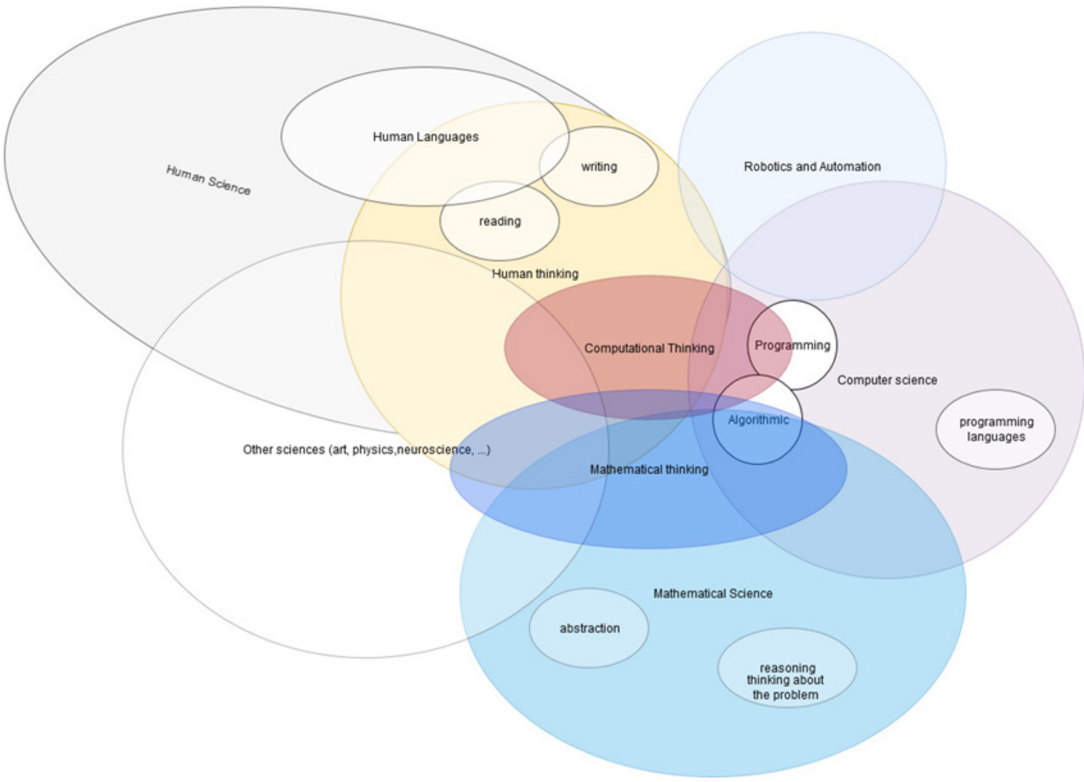
Two key categories were addressed in this article: programming jobs, which should unquestionably monitor the evolution of programming languages, and non-programming jobs, which do not require coding syntax for programming languages but will require mastery of computer programming logic and the high-level language appropriate to the industry, such as jobs that employ new data analytics tools. It is clear that only a small but critical proportion of future jobs will demand digital skills with advanced programming languages and STEM skills. Basic and intermediate programming skills will be necessary to implement and code digital tools in the future digital economy. Most future jobs across various industries will require digitally skilled workers to configure, interact with and use digital tools. In response to this creation and adaptation process, different for-profit, non-profit, governmental and international initiatives have emerged to provide different learning options to adapt the current workforce to digitized processes and provide the new generation with the skills required for the new digital economy.

Recent forecasts suggest that technology will simplify programming languages and allow not only advanced digitally skilled workers to design and programme new services or applications but anyone sufficiently skilled to interact with emerging digital interfaces. Finally, while the digital economy promotes digital and computational learning at all educational stages, interest has shifted toward what is termed **post-AI or human computing**,[9] in which AI machines will collaborate with humans to achieve certain tasks, and towards the effects of **computational thinking** and human thinking and the ambition to usher in a new era of **computer-based math** (Wolfram, 2020), in which we can solve complex problems that have hitherto remained unsolved.

Neuroscientists are investigating the possible benefits of combining human and computational thinking to solve more complex human and universal problems. This poses different challenges with respect to learning tools, approaches, learning age and the specific problems to be solved. It is also important to note that human computing advocates aim to solve more complex problems by combining human and computational thinking but also to boost human creativity, which is a priority in the digital economy that seeks to construct a new generation of innovative digital products and services. Figure 2.6 depicts the possible interactions between these concepts and paves the way for discussion of this post-AI digital human computing.

We believe that the overlapping zones between human thinking, computer science, and mathematical science should be investigated to understand the extent to which computational thinking (Yasar, 2016) complements mathematical thinking and human thinking. The overlapping zones between mathematical thinking, computational thinking and all other sciences are key avenues for investigation in the new complex problem-solving and human creativity process.

Figure 2.6. Human thinking and 'computational' thinking: beyond digital skills




Source: Authors' own 2020, unpublished

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# Bibliometric analysis for mapping digital skills for future jobs

*By Elyn L. Solano-Charris, Carolina Velásquez-Mora & Estephanie Silva-Avellaneda*

## Introduction

In recent years, the world has been immersed in a great tide of technological changes characterized by rapidly advancing innovation in digital technologies – such as artificial intelligence (AI), the Internet of Things (IoT), robotics and blockchains, among others – which has had a significant impact on daily jobs worldwide.

Since the first industrial revolution and the first major developments in technologies, employment in industrialized nations has risen substantially over the medium-to-long term (Brandes & Zobrist, 2017). Automation has created more jobs worldwide than it has destroyed. As mentioned by Brandes and Zobrist (2017), around 200 000 of the 800 000 new jobs created between 1990 and 2013 can be attributed to automation. However, while many fears regarding future jobs emerged during the first industrial revolution, such fears have proven to be unfounded (Brandes & Zobrist, 2017).

The future of work is not only influenced by automation but also by the interaction of other megatrends, including globalization, demographic change, environmental sustainability, urbanization, increasing inequality and political uncertainty. All of these factors are important when trying to analyse the future of the labour market and the skills required (Bakhshi et al., 2017).

Education and training institutions must adapt to the challenges of automation and digitization with a highly practical orientation and accelerated changes in vocational training to respond to evolving occupational profiles and skills requirements. Moreover, further training and retraining will also be important, since employees will have to engage in lifelong learning to be capable of responding as rapidly and effectively as possible to changes caused by automation and digitization (Brandes & Zobrist, 2017).

In this article, a bibliometric analysis was used to map digital skills with future jobs using the Scopus database (www.scopus.com), including a data set composed of scientific articles from academic journals. Contributions were analysed to identify the main skills denoted in the digital economy. Results indicate the most influential countries, authors and institutions, as well as their suggestions on developing the skills and abilities required for digital transformation. Furthermore, a first approach linking skills, abilities and the nature of jobs and educational programmes is suggested.

Finally, future lines on the subject are provided for researchers and practitioners.

The rest of the paper is organized as follows: the next section introduces the data-collection criteria and methodology; the third section describes the results and the fourth section the discussion of research trends and future lines; and the final section provides some conclusions.

## Data collection and methodology

The methodology implemented to define the state-of-the-art of digital skills for future jobs is based on bibliometric analysis. Bibliometric analysis is considered the perfect combination of statistics and analysis of big data to understand basic phenomena, with a well-organized database (Chang et al., 2020; Pourkhani et al., 2019; Muñoz-Villamizar et al., 2019; Pritchard, 1969; Merigó et al., 2018). Nowadays, this method is widely employed in scientific research to study the relevance of a research field, the most prolific researchers and the most-cited contributions, among others (Chang et al., 2020; Yeung et al., 2018; Nederhof 2006).

Our bibliometric analysis is based on literature recorded in the Scopus citation database (www.scopus.com), since it is defined as one of the

Table 3.1. Summary of methodology used

| | |
|---|---|
| **Unit of analysis** | Articles focused on digital skills, digital transformation and education |
| **Type of analysis** | Qualitative and quantitative |
| **Query string** | Using the keywords that were associated with each of the concepts of this research, the following query string was created: TITLE-ABS KEY (skill* OR competenc* OR capabilit* AND digital* OR industr* 4.0 AND education* OR job*). |
| **Download date** | 6 February 2020 |
| **Total number of articles evaluated** | 433 |

Source: Authors own 2020, unpublished

largest citation databases available with high-quality peer-reviewed journals, books and proceedings (Elsevier, 2020).

First of all, the keywords 'digital skills', 'digital transformation' and 'education' were included in the Scopus search tool to obtain a first list of articles combining these three terms in the title, abstract or keywords. Then, a new and complete query string was defined (see Table 3.1).

An initial set of 433 publications published between 2002 and 2020 was obtained from the database search. After an exhaustive and detailed analysis of these documents, 304 papers published between 2014 and 2020 were selected due to their relevance and quality. The results were then filtered by subject area, keywords and year. The VOSviewer software developed by van Eck and Waltman (2010) was applied to define the most representative authors, the location (country) of the institution the author(s) are affiliated with, and keywords in the digital transformation field.

VOSviewer collects data and generates maps based on bibliographic coupling, co-authorship, citation and co-occurrence of keywords (van Eck and Waltman, 2010; Muñoz-Villamizar et al., 2019). To easily understand this analysis, the definition of each concept based on Kessler (1963) and Small (1973) over the VOSviewer functions was considered in this study, as follows:

- Co-occurrence of keywords shows the most common keywords used by different papers. These keywords usually appear as a network connection map that visualizes the most frequently used keywords and interconnection among them (Cancino et al., 2017).
- Citation analysis measures the most-cited papers, journals, authors, etc.

## Results

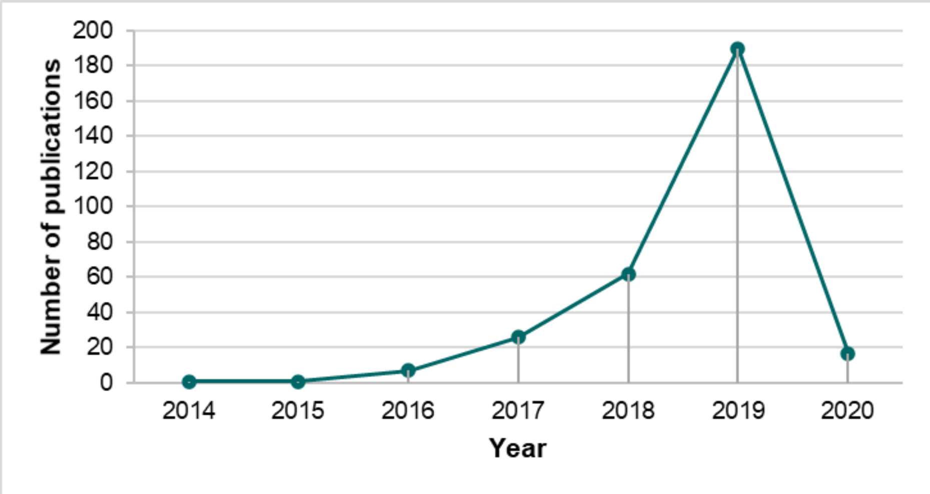
Based on the previous methodology, the keyword analysis and most-cited papers, the leading articles and sources, countries' participation and the evolution of the literature in the topic is provided below.

Chart 3.1 represents results in terms of yearly evolution. The first article related to these topics was published in 2014 (Jaschke, 2014). This first paper focuses on the facilitation of mobile learning processes in technical, vocational and engineering education as well as their integration in the learning process of job scenarios in Industry 4.0. In 2015, a published article focused on understanding how prepared the world is for the fourth industrial revolution. Since 2016, there has been a growing trend in the number of publications. The year with most relevant results was 2017, with 21 documents; 2018 almost tripled the number of publications with 62 documents; and 2019 represents the year with the most publications with 190 documents. Compared with 2017, 2018 represented 195 per cent growth and 2019 saw growth of 804 per cent. So far in 2020, there are already 17 documents. Notably, the last four years (2017–2020) represent 97 per cent of the total documents registered since 2014.

### Keyword analysis and most-cited papers

Keyword analysis is one of the most vital bibliometric analysis tools (Merigó and Yang, 2017; Muñoz-Villamizar et al. 2019). This analysis shows the main topic trends and how they are interconnected. Furthermore, analysis of the main keyword has the capacity to establish researchers' main concerns. Figure 3.1 shows the 152 (out of 6 972) most common keywords, with a minimum

Chart 3.1. Annual publications in digital skills, 2014–2020




Source: Authors own 2020, unpublished

of 10 occurrences. Each circle represents a keyword; the bigger the size of the circle, the higher the number of publications that have the corresponding keyword in their title or abstract. This map is divided into four main topics.

(1) The red cluster, focused on industry (e.g. Industry 4.0, skills, digital technology, job transformation, etc.).

(2) The green cluster and (3) the yellow cluster are both focused on the educational processes and skills that need to be developed for Industry 4.0 (i.e. technical education, innovation, research, creativity, university education, critical thinking, analysis, etc.).

(3) The blue cluster represents the capacity development in the workplace represented by process solutions, higher education, strategy, software development, software effectiveness, etc.

Another important tool in the keyword analysis is the timeline of evolution of keywords to define the most recent specifications of topic trends. This analysis is shown in Figure 3.2. The yellow cluster shows the most recent topics, i.e. data analytics-oriented, along with critical thinking, big data, platforms, science, strategy, creativity, etc. It is followed by the original red cluster, which is more focused on Industry 4.0 and has now become the green cluster. Finally, the purple cluster is the oldest one (i.e. technical education-oriented).

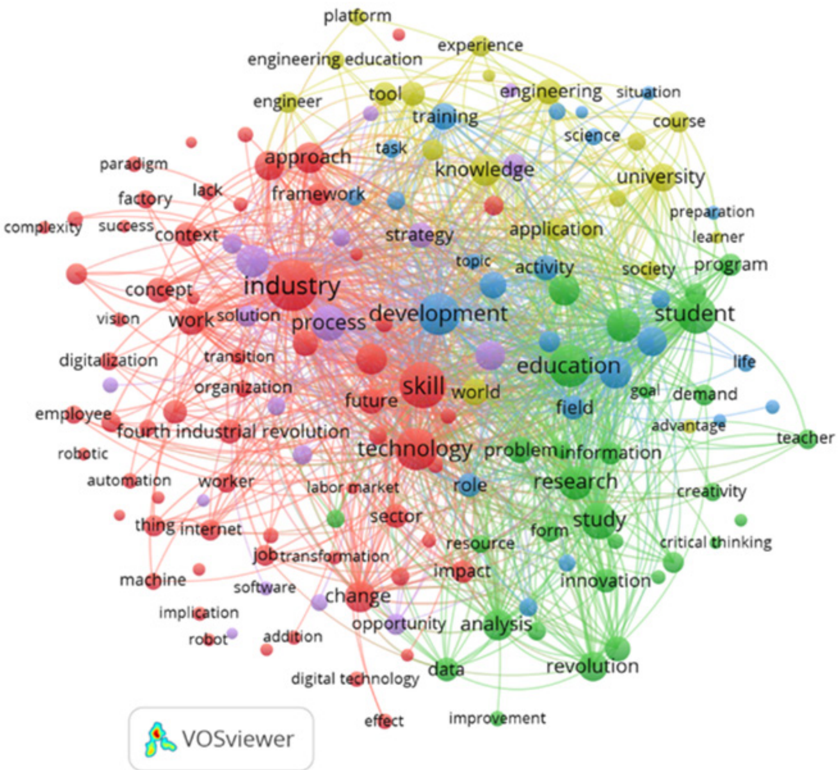
## Leading articles and sources

Regarding the impact of contributions and sources, Table 3.2 shows the top 10 journals focused on the skills and abilities required for digital transformation in Industry 4.0 that have a minimum of 20 citations. The most important journal was *Procedia Manufacturing*, as it has the highest number of cited articles. Other important journals are *Procedia CIRP* and the *Journal for Labour Market Research,* and together these three journals have more than 328 citations. Table 3.2 shows the journals indexed in Scopus that are responsible for the most-cited articles (20–94 citations) related to digital skills and digital transformation.

## Research contributions by countries

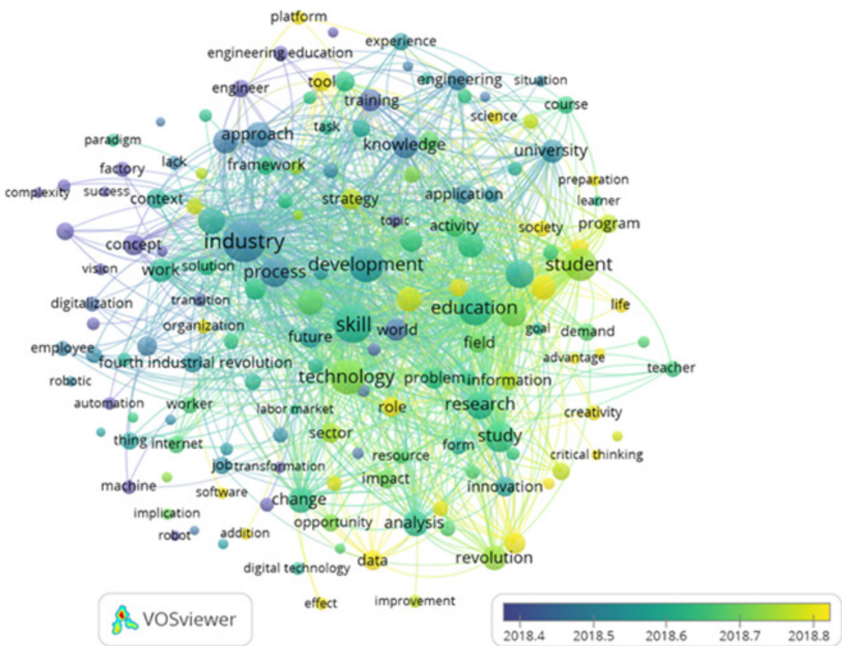
Concerning the research contribution by country, Table 3.3 shows the top 10 countries with the highest number of publications according to the location (country) of the institution with which the author(s) is affiliated. It is important to note that the contributions of these 10 countries represent 48 per cent of the documents published in the area, out of 65 countries that have published at least one scientific document related to the topic. There is no significant variation between countries' publications, citations and total link strength (i.e. the number of publications in which two keywords occur together).

Figure 3.1. Co-occurrence of author keywords




Source: Authors own 2020, generated with VOSviewer, unpublished

Figure 3.2. Evolution of author keywords co-occurrence




Source: Authors own 2020, generated with VOSviewer, unpublished

Table 3.2. Sources with the highest number of citations

| Title | Year | Number of citations | Journal | Authors |
|---|---|---|---|---|
| Tangible Industry 4.0: A scenario-based approach to learning for the future of production | 2016 | 94 | Procedia CIRP | Erol, S., Jäger, A., Hold, P., Ott, K., & Sihn, W. |
| Holistic approach for human resource management in Industry 4.0 | 2016 | 90 | Procedia CIRP | Hecklau, F., Galeitzke, M., Flachs, S., & Kohl, H. |
| Industry 4.0: A Korea perspective | 2018 | 57 | Technological Forecasting and Social Change | Sung, T. K. |
| Is the fourth industrial revolution a panacea? Risks toward the fourth industrial revolution: Evidence in the Thai economy | 2019 | 40 | International Journal of Innovation, Creativity and Change | Sae-Lim, P., & Jermsittiparsert, K. |
| Digitization of industrial work: development paths and prospects | 2016 | 34 | Journal for Labour Market Research | Hirsch-Kreinsen, H. |
| Learning factory: The path to Industry 4.0 | 2017 | 32 | Procedia Manufacturing | Baena, F., Guarin, A., Mora, J., Sauza, J., & Retat, S. |
| STEAM as an innovative educational technology | 2017 | 28 | Journal of Social Studies Education Research | Shatunova, O., Anisimova, T., Sabirova, F., & Kalimullina, O. |
| How will change the future engineers' skills in the Industry 4.0 framework? A questionnaire survey | 2017 | 28 | Procedia Manufacturing | Motyl, B., Baronio, G., Uberti, S., Speranza, D., & Filippi, S. |
| Transition towards an Industry 4.0 state of the LeanLab at Graz University of Technology | 2017 | 26 | Procedia Manufacturing | Karre, H., Hammer, M., Kleindienst, M., & Ramsauer, C. |
| Educating engineers for Industry 4.0: Virtual worlds and human-robot-teams: Empirical studies towards a new educational age | 2016 | 20 | Paper presented at IEEE Global Engineering Education Conference | Richert, A., Shehadeh, M., Plumanns, L., Gros, K., Schuster, K., & Jeschke, S. |

Source: Authors own 2020, obtained from Scopus, unpublished

## Discussion

### Demands of the digital economy

The fourth revolution is creating a digitally enabled environment around the world that is affecting every company because digital innovation can transform practices, improve performance and increase growth across all industry sectors (Australian Industry Group, 2018).

Hence, advancements in AI, IoT, cloud computing, big data, e-commerce and blockchain, among other technological developments, are transforming the nature of the link between

Table 3.3. Top 10 countries by number of documents

| Rank | Country | Documents | Citations | Total link strength |
|---|---|---|---|---|
| 1 | Indonesia | 47 | 20 | 4 |
| 2 | Germany | 28 | 214 | 7 |
| 3 | Russian Federation | 25 | 49 | 3 |
| 4 | Italy | 24 | 122 | 21 |
| 5 | Malaysia | 22 | 21 | 13 |
| 6 | Spain | 16 | 28 | 9 |
| 7 | United States | 14 | 27 | 20 |
| 8 | United Kingdom | 13 | 77 | 20 |
| 9 | India | 11 | 19 | 9 |
| 10 | Australia | 9 | 135 | 2 |

Source: Authors own 2020, obtained with VOSviewer, unpublished technology and employment. All these technologies have led to expanded market reach and reduced costs, which have facilitated the development of new products and services. Moreover, these technologies have transformed the way goods and services are produced and delivered, as well as the business models used in companies, including both start-ups and big multinational companies (Organisation for Economic Co-operation and Development [OECD], 2014). Nevertheless, just as innovation in the digital economy allows the rapid development of new business models, it can also lead existing businesses to become obsolete.

Businesses from all sectors of the economy are now able to create their operating models around technological resources to improve flexibility and efficiency, and extend their reach into global markets; moreover, digital networks and communication infrastructure provide a platform on which people and organizations create strategies, interact, collaborate, sell, work, seek information and communicate with each other (OECD, 2014).

Therefore, the digital economy requires each collaborator in the workforce ecosystem – i.e. non-profit organizations, education, business community, youth and community, government and the public sector – to support various strategies and functions to create their own set of knowledge, expertise and resources – including research, data, tools, technology, funding and networks, among others – in order to be prepared for the challenges of the digital economy.[1]

Workforce ecosystem interaction generates new companies, occupations and forms of work that also require new skills. Deep changes derived from new ways of generating value in the production and distribution of goods and services also give rise to major opportunities for progress from an economic perspective, i.e. productivity, competitiveness, production growth and employment levels; and from a social perspective, i.e. education, health, access to information, public services, transparency and participation. Moreover, in order to leverage the benefits of the digital economy, workforce leaders, workers, educational systems and governments need to develop a framework, programmes and policies promoting digitization and strengthening public and private investment to that end. Regarding strategies, the following can be considered:[2]

- dual-education programmes to improve coaching, mentoring and management skills that may help boost engagement and job satisfaction;
- experiential learning and development to offer wraparound services, social and emotional learning, positive youth development, college and career exposure activities, hands-on learning, real-world experiences and mentoring to support skill development;
- demand-driven frameworks to prepare youth for direct employment;
- career pathway models to incorporate input from the business community while identifying skills needed for their specific industries;
- qualification frameworks to outline specific tasks and assessments that demonstrate skills in specific fields;
- feedback loops between youth and the business community;
- Internet access, digital accessibility and social networks, among others.

It is still too soon to define the jobs and skills that will be required in the future labour market. However, some governments have published reports that define their priorities for the future. For example, the United Kingdom in its *Digital skills for tomorrow's world: Interim report* (2014), stated that all jobs and citizens would need to be literate, numerate and digitally literate. In the same way, other studies such as Maisiri et al. (2019) concluded that future job requirements will depend on the sector in which the expert is employed. Some job profiles needed in smart factory systems are related to programming, mechatronics, robotics, data analysis, IoT, design and maintenance of smart systems, process analysis and bionics. In most of these occupations, workers need to acquire generic information and communication technology (ICT) skills to be able to use such technologies in their daily work activities.

Even though there is agreement that digitization will continue to transform skills requirements for employees in the foreseeable future, it is possible to make certain assumptions and to consider general groups of skills required for the digital economy. Employees should display competencies in each of the different groups of skills (technical, managerial, personal and social skills mentioned below) to support the lifelong learning of individuals and their ability to adapt to workplaces and future disruption, and succeed in a digital economy (adapted from Markow et al., 2018).

### Higher education and training systems

Educational and training institutions need to equip workers to respond to the challenges of automation and digitization. Faculty and administrative staff should be engaged in structuring curriculum design while identifying required skills in the coursework and defining the teaching and learning methods, as well as working in coordination with employers regarding their expectations of job skills development.

Permeability between vocational and academic training, as well as a practical orientation, are required from the education and training system. Institutions that effectively integrate learning opportunities to impart these skills will not only train their graduates for career success but will also become effective partners to employers (Markow et al., 2018).

Moreover, after initial training, further training and retraining will also be necessary: "Employees will have to engage in lifelong learning through further training if they are to be capable of responding, as rapidly as possible, to changes in skills requirements triggered by automation and digitalization" (Brandes & Zobrist, 2017, p. 3). Thus, educational institutions should be prepared to provide lifelong learning options to both students and teachers so that they can play an active role in organizations' efforts to keep pace as technology and other workplace transformations make work more complex.

Concerning the digital skills of teachers, qualifications and the ability to adapt to change are important competencies that must be considered in schools and universities because they are the trainers of future generations. Therefore, teachers must develop a series of competencies that allows them to manage properly all technological, pedagogical, informational, communicative and axiological resources (Levano-Francia et al., 2019).

The United Nations Educational, Scientific and Cultural Organization (UNESCO, 2018) has established three areas of digital competencies which are summarized as: (1) understanding and integration of technological competencies, (2) application of technological knowledge to the resolution of real and specific problems, and (3) production of new knowledge from that already generated. In many countries there is still a gap in teachers' digital competencies that is yet to be bridged.

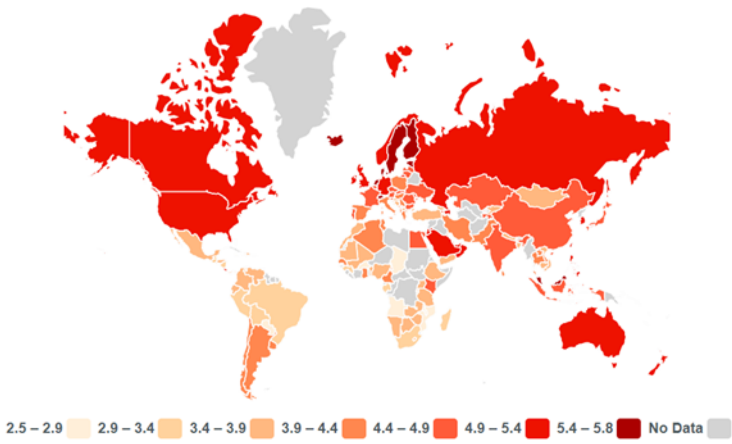
Regarding the general categories of skills for the digital economy, educational institutions and teachers should continue to incorporate strategies for providing technical, managerial, personal and social skills to create:

- *Digital citizens* (people who use digital technology purposefully and confidently to communicate, find information and purchase goods/services).
- *Digital workers* (people who have the ability to evaluate, configure and use complex digital systems. Elementary programming skills such as scripting are often required for these tasks).
- *Digital makers* (people with the skills to build digital technology – typically software development).

Regarding *technical skills*, the most relevant abilities are developing and integrating enterprise information technology systems, knowledge of security standards and communication, virtual communication and media skills, big data analytics, AI and cloud computing. The main *managerial skills* are complex problem-solving, decision-making, service orientation, negotiation, leadership, teamwork, autonomy, task direction, mentoring, job rotation and the ability to work under pressure. The most important *personal skills* are the ability and willingness to learn new things, emotional intelligence, analytical and logic skills, critical thinking, communication and networking, leadership, reliability and responsibility, adaptability, active collaboration, autonomy and creativity. Finally, the most frequently required *social skills* are: teamwork, the ability to be committed and cooperative, the ability to transfer/acquire knowledge, collaboration for synchronization of processes, intercultural and language skills, research skills, civic skills, professional ethics and cognitive flexibility (Sallati et al., 2019; Maisiri et al., 2019; Jerman et al., 2019).

Educational programmes should adopt smart curricula, including computing communication as a

Figure 3.3. Digital skills among population, 2019




Source: World Bank (2019) & World Economic Forum (2019))

core element. Differentiation and personalization, modularity, self-management programmes, strong professional ethics, student-centred pedagogies, competency-based assessment, collaborative learning environments, virtual learning environments, interdisciplinarity and management training, real-world problem applications and innovative pedagogy are all priorities in educational programmes. To address these challenges, reform of the educational paradigm and revisions of traditional pedagogy and curricula are needed. This transformation should be based on critical analysis of the use of ICT tools and digital content in classrooms, and blended and online learning (UNESCO, 2020). Through technology, educational programmes may provide meaningful learning experiences that can increase student motivation, engagement, collaboration and hands-on learning opportunities which allow for learning at all levels and increase student confidence (Marie & Kaur, 2020).

## The gap between educational systems and the digital skills required for future jobs

In the past few years, governments, academia and industry have been remarkably concerned about the skills and abilities needed in the digital transformation era for future jobs. This can be seen in the World Bank report on digital skills among the population (World Bank, 2019) that shows the proportion of the labour force that has enough digital skills (e.g. computer skills, basic coding, digital reading) and rated the extent of those skills in a range of: 1 = not at all; to 7 = to a great extent (see Figure 3.3). The top 10 countries out of 141 and their respective rates are: 1. Finland (5.83), 2. Iceland (5.67), 3. Sweden (5.67), 4. Netherlands (5.63), 5. Singapore (5.66), 6. Israel (5.50), 7. Switzerland (5.47), 8. Estonia (5.43), 9. Denmark (5.42) and 10. Malaysia (5.37). The country with the lowest rank in the report is Angola, with a rate of 2.45.

A strong effort has been perceived from the top 10 countries' governments as they have invested economic resources in developing research into digital transformation, as well as implementing changes in their educational systems to respond to market demands.

However, the digital economy requires higher investment by governments in providing open access to the Internet, better Internet connectivity, development of infrastructure and networks. Moreover, governments, businesses, educational systems and society need to work together to support a dynamic workforce to constantly redefine the skills demanded for future jobs, called by some authors reskilling and upskilling (Vallor, 2015; Illanes et al., 2018).[3]

Educational systems should focus on reducing the gap between educational programmes and labour markets. Additionally, educational programmes should provide a pedagogical model based on competencies while incorporating digital reskilling and upskilling in the technical, managerial, personal and social fields for digital citizens, digital workers and digital makers. A constant training programme should be implemented for teachers to keep pace with the rapid development of technology and innovation in pedagogical methods, to better support the development of digital skills in their students.

## Conclusions and future research

This article presents a bibliometric analysis for mapping digital skills and future jobs. The analysis is based on a sample of 304 papers. Contributions were analysed to define the main skills denoted in the digital economy, i.e. technical, managerial, personal and social skills. Results indicate the most influential countries, authors and institutions, as well as their suggestions on developing the skills and abilities required for digital transformation.

According to the literature, technological developments such as AI, IoT, cloud computing, big data, e-commerce and blockchain, among others, have created a new interaction between the workforce ecosystem in the digital economy that creates innovative businesses, jobs and forms of work. Hence, some authors consider that a digitally competent employee should have an integrated mix of the technical, managerial, personal and social skills required in the digital economy to increase productivity, competitiveness and employment levels.

Higher educational institutions need to equip workers and citizens for the challenges of the digital economy not only by providing solid initial (basic) training but also lifelong learning opportunities. Therefore, reform of traditional pedagogy and curricula based on critical analysis of the use of ICT tools is needed. Industry and government inputs should be incorporated in the construction of the framework and curricula models, with the purpose of reducing the gap between job market requirements and building the capacities of future workers.

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# Impact of AI on employment

*By Lav R. Varshney*

## Introduction

Ever since the industrial revolution's Luddite movement, which involved violent protests against automation of textile production, there have been periodic warnings that new automation technologies would eliminate numerous jobs (Autor, 2015). Since this first industrial revolution, there have been further technological revolutions driven by new general purpose technologies that have caused significant societal and economic shocks. The second industrial revolution at the end of the nineteenth century and beginning of the twentieth century was associated with widespread deployment of electricity generation and distribution networks, as well as wireline and wireless communication networks. The third industrial revolution after the Second World War was characterized by rapid advances in computing that enabled new ways of generating, processing and sharing information. We are now said to be in the midst of a fourth industrial revolution driven by the general purpose technology of *artificial intelligence* (AI) (Brynjolfsson & McAfee, 2014; World Economic Forum [WEF], 2016).

Notwithstanding the Luddites or apocryphal stories of the lumberjack Paul Bunyan being replaced by automation, elimination of jobs is not the only impact in historical precedents of technological shocks stemming from the introduction of new general purpose technologies that changed the nature of work performed by people and by machines. Often, people were augmented by technologies to yield better performance, e.g. one can imagine Paul Bunyan working with a chainsaw rather than being replaced by one. More importantly, new sectors of the economy arose, with novel kinds of jobs.

Although there is significant debate, some argue that this fourth industrial revolution may have different structural effects on the economy and society than previous revolutions (Vermeulen et al., 2018; Borland & Coelli, 2017; Balsmeier & Woerter, 2019). There may be a different balance between job elimination and job creation than before (Acemoglu & Restrepo, 2018; Acemoglu & Restrepo, 2019). In fact, since AI is a general purpose technology, future AI research and development policies may play a significant role in determining whether more jobs are created than eliminated (Wilson et al, 2017; Acemoglu & Restrepo, 2020). Some have argued that there is a strong ethical case for slowing the deployment of AI technologies to prevent widespread societal disruptions (Wright & Schultz, 2018). Others ask whether humans should even work or instead pursue leisure activities when automation can take care of basic needs, and whether work is needed for meaning in human life (Santos et al., 2020).

In fact, appropriately structured human-AI teams may be even more powerful than either alone (Seo et al., 2019), so there is a need to investigate the economic and employment possibilities of humans with augmented intelligence. In fact, different knowledge, skills and personality traits may be more useful for working jointly with AI in the best manner than for performing the same task alone. For example, in human-AI joint creativity, the social intelligence of the human partner may be even more important than their individual creativity.[1] As a classic example, in past chess competitions where humans could compete with AI assistance (so-called centaur chess or advanced chess), one could rank teams as follows: "(1) a chess grand master was good; (2) a chess grand master playing with a laptop was better. But even the laptop-equipped grand master could be beaten by (3) relative newbies, if the amateurs were extremely skilled at integrating machine assistance. 'Human strategic guidance combined with the tactical acuity of a computer,' concluded [Gary] Kasparov, 'was overwhelming'" (Thompson, 2013). As a more recent example, top amateur Go players augmented with the top AI system for Go (Google's AlphaGo) can generally beat the AI alone, so in this sense a human with augmented intelligence is stronger than an AI system alone (Mozur, 2017).

Empirical results show that automation of jobs driven by the introduction of new AI technologies are indeed starting to have an impact on employment around the world (WEF, 2016; WEF, 2019; Dengler & Matthes, 2018). Moreover, several recent analyses have characterized which jobs are most at risk for elimination from AI-based automation in the future (Arntz et al., 2017; Chui et al., 2016). Since different geographies have different mixes of job roles and skill sets, these predictive models can also be used to characterize which cities, rural regions, states or countries may be most affected (Frank et al., 2018; Frank, et al., 2019).

In the remainder of this article, we will detail both the empirical results and predictive characterizations of AI automation's impact on employment. We will also discuss what these characterizations imply for downstream effects such as people acquiring new skills to move into new job roles. The purpose of this review is to inform the design of economic and social policies that help people not just survive in the age of AI, but thrive.

## Empirical findings on the impact of AI on employment

In this section, we review studies on the impact that AI is having on employment (WEF, 2016; WEF, 2019; Dengler & Matthes, 2018). In a global survey of employers carried out by WEF in 2016, only 9 per cent of respondents believed that advanced robotics and autonomous transport (key applications of AI) would be technological drivers of change by 2018–2020. Further, only 7 per cent of respondents believed that AI and machine learning would be technological drivers of change by making it possible to automate knowledge work tasks, and thus cause a decline in demand for cognitive skills. This was compared to 34 per cent for mobile Internet and cloud technology (WEF, 2016). Since that time, however, AI has gained even more abilities.

One should note that the pace of AI research, in terms of achievable technological abilities and economic impacts, is notoriously difficult to predict. For example, AI researcher Herbert Simon famously (and inaccurately) made the prediction in 1965 that, "Machines will be capable, within twenty years, of doing any work a man can do" (Simon, 1965). Further, it has often been observed that contrary to traditional assumptions, it is easier to develop AI for high-level conscious reasoning that is difficult for humans than for low-level sensorimotor skills (Minsky, 1986). As Hans Moravec (1990) wrote, "it is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility".

Further, there are other barriers to making accurate predictions about the interaction of AI with employment. There is lack of high-quality data about the nature of work, including the dynamic task requirements for various occupations. There is also a lack of empirically informed models of microlevel processes such as skill substitution and humans with augmented intelligence. Finally, there is insufficient understanding of how AI technologies interact with broader societal dynamics such as migration (Frank et al., 2019).

In a 2018 study focused on Germany, occupations were decomposed into smaller tasks and these tasks were assessed by experts for probability of automation using non-machine learning techniques. Assuming only certain tasks can be substituted, they found that at the time of the study, 15 per cent of German employees had jobs that could be substituted by AI. The study also showed an empirical relationship between automation risks and employment growth (Dengler & Matthes, 2018).

Further studies have not just assessed current jobs that can be automated through AI technologies but also made predictions about the future. Yet there is considerable debate on which jobs may be eliminated due to AI, with estimates ranging from 38 per cent of American jobs to only 9 per cent (Arntz et al., 2017). Again, this difference is largely attributed to whether the analysis is performed at the level of complete occupations – which leads to higher estimates – or at the level of decomposed tasks within occupations, which gives lower estimates. In particular, there is substantial heterogeneity of tasks within occupations as well as the adaptability of jobs in the face of technological advances, and workers evidently specialize in non-automatable niches within their profession.

A further report focusing on what will happen around the globe by 2030 suggests that 60 per cent of occupations have at least 30 per cent of work tasks that can be automated (Manyika et al., 2017), which will change the nature of many occupations even if they are not eliminated. Moreover, there will be significant creation of new job categories due to technological change. Although the majority of jobs will, by 2030, have the possibility of AI-driven automation, the number of jobs actually changed will not be as high due to technical, economic and social factors that affect adoption. Models also predict that by 2030, 75 million to 375 million workers around the world will need to switch occupational categories (Manyika et al., 2017). We consider such migration next.

## Downstream impacts: Job migration via reskilling

In this section, we focus on how significant variation in the job loss characterizations mentioned above also implies a variety of approaches to understand the downstream impacts (like shifting to new jobs via skill acquisition) of the technological shock of AI. In particular, we describe average-case approaches that consider ensembles of predictions as well as worst-case approaches. Note that there have been studies on the distribution of skills throughout jobs in the United States with respect to automation (Frank et al., 2018; Frank, et al., 2019) and others that try to assess the possible effects of automation (Chui et al., 2016; Youn et al., 2016).

Several recent analyses have characterized which jobs are most likely to be eliminated by AI-driven automation (Arntz et al., 2017; Chui et al., 2016; Manyika, et al., 2017). Combining these analyses with data on the geographic distribution of job roles and occupations allows one to characterize which cities or countries may be most affected. Frank et al. (2018) and Frank et al. (2019) do so using estimates of which jobs are most likely to be eliminated due to AI-based automation, taking an average-case view of the previous analyses of which jobs are likely to be automated. In comparing large cities to small cities in the United States, it was found that small cities will need greater employment adjustments, such as worker displacement and job content substitutions. Large cities, however, have more managerial and technical professions that require specialized skills that are not easily automatable, reducing the potential impact of automation there (Frank et al., 2018).

Geographical migration has long been considered one of the key mechanisms through which labour markets adjust to economic shocks, such as those created by the introduction of new technology. Such geographic migration has been observed empirically in response to AI technologies (Faber et al., 2019). However, rather than moving physically, people may try to migrate into new jobs and industrial sectors while remaining in the same place geographically. Indeed, providing training to enable people to move into new job sectors has been a standard policy response to the AI revolution,[2] though it is worth noting that personal qualities may also impact the ability to migrate occupations (WEF, 2019). There are limited studies on the dynamics of how this process may play out, cf. Frank et al. (2019). In fact, migration models such as gravity and Markov models from the study of human migration (Ginsberg, 1972) can be adapted to understand how this shift may happen. Such migration models have rarely been used to study occupational change (Stewman, 1976) but never in the context of technological shock, e.g. from AI, except in our own unpublished work.[3]

Given the difficulty in characterizing and predicting AI advances, one can take a worst-case rather than average-case view of the technological shock, to consider the impacts of eliminating the most common job in a given locality. This eliminates the significant uncertainty in assessing and making predictions about which occupations are most amenable to AI-based automation.

One typical dataset for such an investigation includes data from the United States Bureau of Labor Statistics (a common source of data for such investigations (Mark, 1987)) that captures the job distribution in each metropolitan or rural area. This includes the Occupation Employment Statistics programme,[4] which produces employment changes and wage estimates annually at national, state and city levels. Another typical dataset is the Occupation Information Network (O*NET) database,[5] which can be used to introduce the notion of job distance, allowing a measure of the difference between jobs based on the skillsets required to successfully perform them.

The O*NET database contains hundreds of standardized and occupation-specific descriptors obtained by surveying a broad range of workers from each occupation. O*NET classifies occupations into one of five *Job Zone* groups, which are ranked based on the level of education, experience and training necessary to perform the occupation. Zone One jobs require little or no preparation whereas Zone Five jobs require extensive preparation. Each job has descriptors that define the attributes of the job: abilities, interests, knowledge, skills, work activities, work styles and work values. Each of these descriptors has additional sub-descriptors with an individual rating from zero to 100. A final type of dataset that is useful for such investigations is the Job Openings and Labor Turnover Survey (JOLTS) dataset,[6] which is also from the Bureau of Labor Statistics. JOLTS keeps an up-to-date record of each industry and its corresponding rate of average job openings, hires, quits, and layoffs and discharges.

Drawing on the aforementioned datasets, we performed this kind of worst-case analysis and our results are in fact reminiscent of results from an average-case analysis (Frank et al., 2018). What we found[7] is that rural areas are less robust to automation than are metropolitan areas, since occupations are more concentrated in rural areas and so the absorption of displaced workers is not spread out. In this sense, larger cities may be more resilient to automation by having broader absorptive capacity.

## Conclusion

In this article, we have reviewed several studies on the impact that AI may have on employment both globally and in specific geographies such as Germany and the United States. These studies characterize which occupations may see modification due to machine-augmentation, which may be eliminated, and which kinds of new occupations may arise due to technological change, and then provide aggregate statistics across many industrial sectors or even the whole economy. As we have discussed, such characterizations and predictions are difficult not only due to a paucity of detailed data and models of job reskilling and migration, but also due to the fundamental unpredictability of developments in AI abilities. In fact these uncertainties may be magnified in attempting to understand downstream dynamics of how people may react to job elimination. As such, we also described the idea of drawing on models of human migration from mathematical sociology in a worst-case manner to understand the impact of AI-driven automation downstream.

These empirical findings and model-based predictions can specifically be used by policymakers to develop appropriate policy responses; for example, to determine which kinds of digital reskilling programmes may be more effective and which geographical areas may benefit from them the most. On the other hand, research findings show that there are several job categories with tasks that are resilient to AI-based automation and there are geographic regions that may be intrinsically robust. These findings can be used to focus resources where there is greatest need while maintaining appropriate fairness.

AI techniques are already being used to model and predict a variety of societal and economic processes, and even to develop optimal public policies using mechanism design and reinforcement learning (Zheng et al., 2020). Going forward, it may be feasible to use AI itself to better predict the impact AI will have on employment and on human life more broadly, and then develop appropriate policy responses.

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# Digital skills for gig workers in digital platforms

*By Hilda Mwakatumbula and Goodiel Moshi*

## Introduction

Africa is home to the youngest population in the world. The United Nations Development Programme estimates that by 2055, the continent's youth population (15–24 years old) will reach 226 million.[1] Youth can be a blessing; however, as with any resource, unless adequately managed it can become a burden. African youth face several challenges in integrating with the global economy, including pervasive unemployment due to low education levels (Coulibaly et al., 2019). Most African youths live in poverty and some opt to migrate abroad in search of greener pastures. As the world approaches the Fourth Industrial Revolution, African governments have a significant role to play in addressing issues facing youth.

The Fourth Industrial Revolution has led to migration to the digital economy as the world becomes more digitized and sophisticated every day. New technologies play a critical role in all sectors of the economy and have an impact on interactions within society and thereby the labour market (Leahy & Wilson, 2014). The changing digital landscape forces workers to continually update their skills to remain competitive in the labour market. In the United States, 82 per cent of middle-skilled jobs are digital-intensive, and workers with digital skills have higher remuneration (Bradley et al., 2017). Today, countries seek to update their citizens' skills to ensure that everyone can participate fully in the economy and that employers in all sectors can hire the necessary digitally skilled employees. Most developed countries, including the United States and United Kingdom (UK), and regional organizations such as the European Union and Organisation for Economic Co-operation and Development, are working hard to scrutinize skill demand in current and future labour markets.[2]

In the sub-Saharan Africa (SSA) region, governments are dedicated to adopting the digital economy as a lever for stimulating economic growth, improving the quality of service delivery and enhancing job creation. Some countries in the region (e.g. Rwanda) have made tremendous progress in creating an enabling environment for information and communication technologies (ICTs) (World Bank Group, 2020). However, several hindrances lie ahead, including the growth of the young population primarily into the low-skilled labour force, the prevalence of the informal labour economy and the inadequacy of inclusive social protection policies. While digital technologies have the potential to create new career opportunities, digital illiteracy excludes a sizeable population in the region from adapting to new technologies, limiting their potential participation in the digital economy (Choi et al., 2020). Thus, building human capital, specifically in digital skills, is critical for the region to leverage the benefits of the digital economy. The region must analyse the essential digital skills required to participate in the digital labour market as a step towards building a literate society.

This study analyses the essential digital skills required to participate in the digital labour market. To do so, it deploys qualitative methodology to gain qualitative knowledge of digital skills from the perspective of workers in the gig economy. The gig economy in this study will adopt the definition of Mastercard and Kaiser Associates (2019), referring to *digital platforms that allow freelancers to connect with individuals or businesses for short-term services or asset-sharing*. The total value generated from the gig market was USD 204 billion in 2018, and it is expected to rise to USD 455 billion in 2023 (Mastercard and Kaiser Associates, 2019). Our research examines the digital labour market using the case of the Uber gig digital market platform in Tanzania. The gig digital market platform is explored due to its ability to provide job opportunities for low-skilled people. Furthermore, Uber is among the fastest-growing digital platforms in Africa, with 150,000 active drivers and five million riders in the region.[3] The Tanzanian case was selected because the country has the largest skilled digital workforce in the East Africa region (12 per cent) and the fifth largest in the SSA region (World Bank Group, 2020). Finally, the study offers recommendations to policy-makers to build a digitally literate society and thereby leverage opportunities in the digital economy.

The remainder of this study is organized into six sections. The next section examines the relationship between the labour market and the gig market economy, offering details on the changes in the labour market landscape due to digital technologies and the emergence of the gig labour market. Because a skilled digital workforce is crucial to participate in the labour market and to take advantage of gig market platforms, the third section emphasizes digital skills. It defines digital skills and explains the different levels of digital skills required by various sectors. The fourth section subsequently provides feedback from focus group discussions and interviews with gig workers on the Uber platform on essential digital skills. The fifth section analyses the essential skills needed for gig labour markets (using the case of Uber). Finally, the last section presents a synopsis of the study, including policy implications for improving the acquisition of digital skills in the Tanzanian labour force.

## The labour market in the gig market economy

The labour market is currently in the midst of a dramatic transformation as the result of the Fourth Industrial Revolution, which is characterized by technological innovation, artificial intelligence, robotics and digitization (Vandaele, 2018). A further feature of the Fourth Industrial Revolution is the digitization of the economy, including the emergence of the digital platform economy (Chan et al., 2018). Digital platforms have created online structures that facilitate a wide variety of human interactions and activities. Platforms are multifaceted digital frameworks that alter the way people socialize and work, thereby impacting the value chains of production and profit margins (Kenney & Zysman, 2016).

Digital platforms, through the application of big data, artificial intelligence and cloud computing, are shifting the nature of work and economic structures (Wood et al., 2018). Digital platforms can be mainly categorized into capital platforms – like Airbnb connecting customers with renters (sellers) – and labour platforms such as Uber, which connects customers with service providers to offer either physical services (gig work) or virtual work. These platforms are becoming handy with global platforms like Google and Facebook for advertising and retail. The growth of digital labour platforms led to the emergence of the gig economy that introduced modern employment practices (Taylor et al., 2017). According to Heek (2017), around 70 million people – approximately 2.3 per cent of the global workforce worldwide – have registered for gig work online.

The gig economy is comprised of online platforms that connect service providers to consumers for a particular gig (or job) based on on-demand commerce. Clients can request services through the digital platform via the Internet or mobile-based application, which allows them to access providers and request services. The provider (gig worker) can access the request and communicate with the client on the platform, offer the requested service, and receive compensation (Donovan et al., 2016). According to Kalleberg and Dunn (2016), gig companies' platforms can be placed into four categories based on worker's control and wage: crowdwork (e.g. clickwork.com), transportation (e.g. uber.com), delivery/home tasks (e.g. taskrabbit.com), and online freelance platforms (e.g. freelancer.com). This study focuses on a transportation platform (uber.com) in Tanzania.

Transportation platforms such as Uber and Bolt have greater controls but higher wages in comparison to other platforms. Such platforms require background checks and strict branding rules. In addition, employees experience low autonomy but require limited specialized skills (Kalleberg & Dunn, 2016). The low skill requirements in reading and numeracy to participate in the transportation platforms' labour market makes it appropriate for the SSA region, where the prevalence of poorly educated and low-skilled workers is higher than in other regions in the world. The nature of the gig economy reduces the entry barrier for low-skilled workers and offers the chance for individuals to supplement their incomes while maintaining their core jobs.

According to Brown et al. (2018), the digitization of markets has led to labour scarcity, increased the demand for high-skilled workers and reduced the demand for low-skilled workers due to the automation of routine jobs. However, digitization is also creating new opportunities for low-skilled workers through the gig labour market. It takes less than two months to take a driving course and earn a driving licence. Given the high number of low/unskilled youth in SSA, the gig economy is likely to play an essential role in job creation. However, while the entry barriers to the gig transportation economy are low, there are still essential digital skills required to participate in the gig labour market.

Tanzania was the seventh African country where Uber launched its services.[4] After its launch in 2016, the platform attracted Tanzanian youths due to the low entry barriers. It is believed that there are almost five thousand online drivers in Tanzania and nine ridesharing platforms. Other transportation platforms such as Ping.com and Bolt.com are also becoming popular in Dar es Salaam and other large cities in the country. These digital platforms have the potential to unlock employment opportunities, on either a full- or part-time basis. It is crucial to scrutinize the essential digital skills required to participate and thrive in this new labour market and thus build a digital-skilled society to reap the benefits of digital platforms.

## Digital skills

Digital skills are an essential asset not only to employees but also to an unemployed population seeking to participate in the labour market. Digital skills have proven to be necessary for almost all occupations, from primary occupations to managerial positions (Curtarelli et al., 2017). As the workplace grows increasingly connected, digital skills have become of greater interest to employers; thus, the level and type of digital skills determine inclusion in the labour market (Andrews et al., 2018).

As previously noted, the gig economy creates opportunities for individuals in developing countries to participate in labour markets in several ways. One such way is lowering the barrier to entry for individuals willing to participate in the labour market. One essential denominator of gig market modalities is that participation and operation happen in the digital sphere and thus require some level of digital skills for an individual to participate.

To identify the digital skills required to participate in the gig market, it is necessary to first define digital skills. There is ample literature from both academia and industry that attempts to explain digital skills. For example, the European Commission established that digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society.[5] It includes information and data literacy, communications and collaboration, digital content creation (including programming), safety (including digital well-being and competencies related to cybersecurity), and problem-solving (Vaikutytė-Paškauskė et al., 2018).

The UK has established a framework with five essential digital skills necessary for life and work. The framework suggests that communication, handling information and content, transacting, problem-solving, and being safe and legal online were essential skills for every UK citizen.[6] In the same vein, van Laar et al. (2017) categorized digital skills into seven core and five contextual twenty-first century skills. The study listed technical, information management, communication, collaboration, creativity, critical thinking and problem-solving as core digital skills. In addition, ethical awareness, cultural awareness, flexibility, self-direction and lifelong learning were delineated as digital contextual skills. While the study offered a framework for twenty-first century digital skills, it argued that the importance of competence in these skills varies; therefore, there is a need to develop measurement tools for specific industries.

As technology continues to change, the set of required digital skills also changes. While broad definitions attempt to include the most relevant digital skills, Skillsoft (2019) argued that the operationalization of such broad definitions may be dangerous to organizations. Digital skills go far beyond the technology itself, and general descriptions may not be appropriate when applied to some specific environments.

Accordingly, the International Telecommunication Union (2018) categorized digital skills in three levels – basic, intermediate and advanced – but emphasized that acquisition of digital skills demonstrates a continuum phenomenon. For example, basic skills consist of entry-level proficiency while intermediate skills are essential to use ICT in meaningful and advantageous ways.

Advanced skills are required to perform specialized ICT and professional tasks. Ecorys UK (2016) further suggested that digital skills have evolved from the use of computers to the use of mobile, connected devices and embedded technologies.

Furthermore, not all technologies are required for all jobs. For example, given the plethora of software applications, the essential skills required in one job may differ from those in another job. For this reason, Skillsoft (2019) proposed that each organization should use broad definitions to align necessary digital skills to meet its organizational goals, as mapped to specific jobs. Thus, one must consider the type of digital skills needed and the level of digital skills required, in this case, to participate in the gig market. Even for participation in the gig market, there are different types of gig markets and each – such as design/ programming freelancers or transportation gig markets (Kalleberg & Dunn 2016) – requires different levels of digital skills.

This study specifically focuses on the skills required to participate in transportation platforms. Such platforms are characterized by short-duration tasks and require physical presence and no specialized work skills (Kalleberg & Dunn, 2016). In their study, Kalleberg and Dunn identified general job skills, in particular vehicle driving, which on the International Labour Organization scale[7] falls within skill level 2, requiring the ability to read information such as safety instructions, make a record of work completed, and accurately perform simple arithmetical calculations. As the general job skills required in this job are not necessarily digital, a different set of digital skills is required to enable an individual to participate in this gig market.

This study adopts the definition of Hecker and Loprest (2019) for 'foundational' digital skills: "*nonspecialized digital skills that may be important for carrying out a job but are not the job's main substance*". Foundational digital skills are differentiated from high-end specialized digital skills like computer programming, software engineering or digital media design, which may be transacted through digital platforms, usually via freelance platforms. These skills constitute the main substance of the skills needed for the job being delivered. Thus, foundational digital skills, or essential digital skills, are necessary in addition to 'main substance' job skills to enable individuals to participate in the transportation platform market.

## The fieldwork

### Methodology

The fieldwork primarily applied a qualitative methodology, comprising key informant interviews and focus group discussions. The motive was to explore the essential digital skills needed to participate in the gig transportation labour market. Therefore, interviews were conducted with 12 Uber drivers, including the leader of the newly formed Tanzanian Online Drivers Association. Purposive sampling technique was used to select interviewees for an information-rich sample to ensure the study was in-depth (Coyne, 1997; Suri, 2011). Similar to studies on the gig platforms (Adebayo, 2019; Chan & Humphreys, 2018), purposive sampling technique has been used because it is the most effective use of a limited resource by recognizing and selecting the most productive (knowledgeable and experienced) individuals (Patton, 2002).

Among interviewees, 25 per cent were females aged between 20 and 34 years old. Thus, 75 per cent were males, aged between 19 and 43 years inclusively. More than 50 per cent of interviewees were aged between 25 and 35 years old. Further, 30 per cent of interviewees had primary school education, 50 per cent had secondary school education, and 20 per cent had education above secondary school level. The interviews were followed by two focus group discussions to ensure the saturation of data. The first focus group discussion had seven participants and was 100 per cent male. The second group, with five participants, was female-dominated, comprised of 60 per cent females and 40 per cent males.

Both interviews and focus group discussions were conducted in Dar es Salaam, the city in which Uber operates. The discussions focused on understanding essential digital skills and the avenues through which drivers acquire those skills. In these discussions, drivers were offered an opportunity to pose recommendations for improving the level of digital skills among youth. The remainder of this section provides the key findings from the fieldwork.

*“I registered on the Uber platform as a driver in 2017. I walked into their office with almost zero digital skills. The training was helpful to kick-start my journey as a gig worker. I have learned a lot along the way; my level of digital skills has improved tremendously.”*

## Findings

Firstly, it was reported that Uber requires its drivers to attend digital training as part of its recruitment procedure, before starting gig work. About 20 per cent of interviewees reported being conversant with digital platforms before registering as drivers, and approximately 80 per cent were not previously conversant with digital platforms. In its early years (around 2017), Uber offered one-on-one training. However, given the growth of the platform, training is currently provided in groups of about 20 people. Prospective drivers wait for about a week to be scheduled for training, depending on demand. The training is usually offered over one day for an average of six hours.

Secondly, participants reported several digital skills essential for online drivers that fall into six categories: smartphone technical operations, the ability to manage information, the ability to communicate online, critical thinking and problem-solving, online safety, and e-payment/ banking. Most participants suggested that apart from simple smartphone technical skills such as downloading an application, they were not aware of other necessary digital skills prior to the training. One participant explained during the focus group discussions:

Thirdly, the drivers explained that, even after training, it took time for them to master certain skills, particularly technical tasks such as using maps for navigation. Therefore, as a coping mechanism, drivers often request that their customers provide directions to their destination rather than following the map. The drivers also shared that their communication skills improved quickly early on as they interacted with many customers online. However, as the technology changes at a rapid pace, most drivers now lag behind in online critical-thinking and problem-solving skills, as well as online safety. One participant briefly summarized this issue:

Fourthly, the participants emphasized the need to improve the level of digital skills among youth. The participants affirmed that digital skills training is likely to unlock employment opportunities for youth (consider that Tanzania is now believed to have almost 5,000 registered gig transportation workers) and to reduce critical entry barriers to the workforce, as the level of digital skills needed to participate in labour gig markets is low. In addition, the participants suggested that digital skills among youth are likely to unlock income-generating opportunities in other sectors of the economy. Thus, digital skills should be given emphasis by the government to aid the nation to reap the potential of ICTs.

In short, the Uber platform provides basic digital skills training to ensure that their workers are equipped with essential skills before starting their gig. The training lasts approximately six hours, which reflects the low barrier to entry. The training is not sufficient to fully equip drivers with various digital skills but can help drivers to kick-start their gig work. The training covers technical, communication, information management, critical-thinking and problem-solving, online safety and e-payment/ banking skills. Furthermore, the drivers become conversant with additional skills as they interact with customers. However, there is a clear need for periodic training on online safety as well as critical-thinking and problem-solving skills to prepare drivers as technology changes. Finally, participants affirmed that digital skills are crucial to unlock employment opportunities for youth.

*“Most drivers were using their mobile numbers as passwords; consequently, several accounts were hacked. Currently, drivers are keener to ensure their safety online. However, as innovation surges, hackers are innovating new hacking techniques. Additional training, particularly on cybersecurity, is vital to ensure the safety of drivers and customers online.”*

## Essential digital skills for the gig labour market

This section uses Uber as a case study to analyse the essential skills required to participate and thrive in the gig labour market. First, it details why these skills are required for a prospective gig worker based on findings from the fieldwork and literature review. The digital skills dimensions are then analysed against the Uber platform.

The first essential digital skill is technical skill, which refers to the ability to use a smart mobile device and application to accomplish a task. Technical skill requires a worker to know how to operate a mobile device and platform application and to navigate online (Ng, 2012; van Deursen et al., 2016). For gig workers on the Uber platform, it is essential to know how to operate a mobile device (smartphone) and the Uber driver application. A driver must be able to download the application, register and log in.

The second digital skill is the ability to manage information. This skill refers to the ability to access and use information to make informed decisions. Workers in the gig market receive extensive critical information from their clients. Uber drivers receive information about the location and contact details of their clients when accepting a trip. They must understand how to manage that critical personal information. It is essential for drivers not to share that information with a third party. Drivers should use personal information like name and picture to identify the client, and the client's address for easy navigation, to improve the customer's experience. Therefore, the ability of the driver to access and use that information is an essential skill that is crucial to participate and thrive in the gig transportation market.

The third skill is online communication. This skill refers to the ability to communicate with clients online with clarity. Communication is crucial when working in the digitized platform market because clients and providers often have never met. The Uber platform has a specific function whereby the driver can communicate with the client through a short message or call using the phone number from the client's profile. Also, drivers can interact with the platform online, such as launching a complaint online. Therefore, the driver must be an excellent communicator to thrive on a digitized platform like Uber.

The fourth digital skill is critical thinking and problem-solving, which refers to the ability to use ICTs to make informed judgments and choices, and then use the information gathered in solving a problem (Lee et al., 2016; Scherer & Gustafsson, 2015). For instance, if a driver has more than one route option to use on a particular trip, the driver should be able to use mobile applications to analyse the most efficient path at that moment. Several online applications use artificial intelligence and machine learning techniques to assist drivers in making an informed judgment. Google Maps, for example, can analyse the most efficient route or the best option in case of an emergency. Thus, while critical thinking and problem-solving may not be crucial simply to participate in the gig labour market, it is essential to thriving in the gig labour market, because emergencies are inevitable on the road, especially in big cities.

The fifth digital skill is online safety, which refers to digital well-being and competence related to cybersecurity. Cybercrimes are inevitable on every digital platform. Gig workers must have skills to guarantee their security while transacting via the platform. For example, drivers should be aware not to share their password with a third party online or offline. Thus, gig workers need to understand the risks and threats associated when working online and stay safe.

The sixth digital skill is e-payment/banking expertise, which refers to the ability to manage and monitor digital transactions. Uber requires all drivers to have bank accounts prior to working with the platform. Although this requirement may pose a bottleneck, particularly in Africa where a considerable portion of the population does not have bank accounts, given the fact that most of the current Uber operations are in cities where bank services are widely available, this requirement has not been identified as a barrier. As the service continues to roll out in peri-urban areas – where banking services may be scarce – inclusion of other financial inclusion means such as mobile money can be explored. The bank account is used for online transactions, as customers have the option to pay for trips through cash or cards. If a customer uses a card, the driver will see the amount of money in his Uber account. Uber then transfers that money to the driver's bank account once a week. Drivers must therefore understand how e-commerce functions in order to effectively monitor their e-commerce accounts.

This study proposes six essential digital skills for gig workers on transportation platforms. These skills may also be relevant to gig workers on other platforms that require low digital skills to operate, such as handy.com and taskrabbit.com.

## Conclusion

This study opened with an analysis of the challenges facing the world as it migrates towards the digital economy. Digital technologies have altered the labour market landscape, impacting the skills needed to participate in the marketplace. Digital illiteracy restricts a sizeable portion of the population from participating in the digital labour market. However, the low skill requirement (in reading, numeracy and digital skills) to engage in the digital platforms labour market makes it particularly suitable for the SSA region, where the prevalence of a poorly educated and low-skilled workforce is higher than the rest of the world.

Although the entry barriers to participate in the gig labour market are low, specifically in transportation digital platforms, foundational digital skills are still crucial to unleash the full potential of gig markets. Using the Uber platform, this study identified six digital skills that are essential for gig workers to participate and thrive in the labour market: technical, information management, communication, critical thinking and problem-solving, online safety and e-payment/banking. Thus, to ensure the inclusiveness of the workforce participating in the digital gig market economy in Tanzania, it is essential to establish the necessary foundations required to leverage opportunities for the digital platform economy. That includes first **building human capital readiness to participate in the digital economy, and second creating a conducive environment to facilitate innovation and job creation**.

### Human capital readiness

Firstly, to build human capital readiness to participate in the digital economy, Tanzania can **embed digital skills literacy as a core subject within the academic curriculum** in primary and secondary schools. Digital literacy should be emphasized at the same level as numeracy and reading skills. Because primary and secondary school education are free in Tanzania, ensuring that digital skills are taught at these levels will ensure that youth can participate in the digital labour market economy after graduation. To do so, the country may consider training teachers to offer digital literacy skills to students and may provide enabling infrastructures at schools to facilitate digital skills training by practice.

Secondly, as most of the workforce (88 per cent) lack essential digital skills, the country can **establish digital skills centres**. These centres can be used to offer digital skills at an affordable cost and on a flexible schedule. Primary school buildings can be used in the evening and/or on weekends as digital skills centres. This practice will ensure that the majority of the Tanzanian populace, irrespective of education level, are digitally literate and able to participate in the digital labour market. However, training of trainers and conducive infrastructure are required.

Thirdly, the country should **encourage apprenticeships and on-the-job training** as a

Figure 5.1. Digital skills for transportation gig platforms


Source: Authors' own, unpublished

means of training a digitally illiterate society. Apprenticeships and on-the-job training will prepare workers to participate in the digital labour market and foster lifelong learning, which is essential in this era of new technologies and innovation.

### Conducive environment to support innovation and job creation

**Supportive policies** are a vehicle to accelerate innovation and job creation in the digital sector. Most popular digital platforms like Uber are currently founded in developed countries. While it is crucial to offer an enabling environment for these platforms, it is high time to encourage and support local innovations. Although it is beneficial to ensure competitiveness among digital platforms, local innovators should be given both priority and the opportunity to grow and create local employment opportunities. Supportive policies are essential to ensure that Tanzanians reap the benefits of the digital economy, overcome unemployment challenges and enjoy economic development.

Digital infrastructure plays a crucial role in ensuring the provision of high-quality digital skills training. Tanzania may consider **investing heavily in digital infrastructure** to ensure the accessibility and affordability of digital infrastructure for all without discrimination of marginalized communities. Reliable digital infrastructure should include guaranteed complementary physical infrastructure such as electricity.

Therefore, to ensure that Tanzania and other developing countries build human skills readiness and create a conducive environment to support digital innovation and job creation, it is necessary to **establish a national digital skills development strategy**. The development of the digital skills strategy should involve all stakeholders, including policy-makers, regulators, educators and employers. The strategy will help ensure that human capital is ready to embark on the digital era, as well as supporting the careers of those whose jobs were replaced by technology, by repurposing their skills.

### Limitations and direction for future studies

Although this study has managed to offer a framework for essential digital skills to participate in the gig labour market, in particular the gig transportation market, there are various challenges facing workers in the gig market, including lack of social protection. Future studies can emphasize improving the welfare of gig workers, which may involve establishing social protection policy frameworks and lifelong learning programmes for workers in the digital economy.

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# Data citizenship framework: exploring citizens' data literacy through *data thinking*, *data doing* and *data participation*

*By Alicja Pawluczuk, Simeon J. Yates, Elinor Carmi, Eleanor Lockley and Bridgette Wessels*

## Introduction

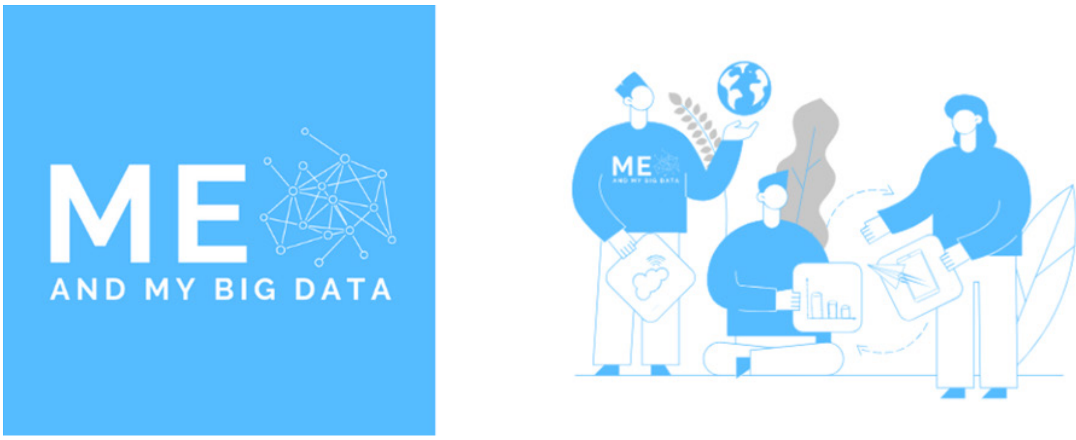
Improving digital literacy is a key policy goal of governments worldwide. A key component of citizens' digital literacy is an understanding of the uses of their personal data. Data literacy encompasses skills and competencies essential for meaningful and informed participation in society in the twenty-first century. In an increasingly digitized and datafied society, it is vital that citizens know how to manage, access and critically analyse their data and data-collection processes. In recent years, in both private and public sectors, data-driven decisions have become central forces influencing and reshaping the idea of citizenship. In light of these changes, it is vital that governments focus on the importance of citizens' data literacy education and training.

A lack of data literacy opens citizens up to personal, social and financial risks – and limits their ability to operate as fully informed active citizens in a growingly digital society. Current policy challenges point to an urgent need to understand and address citizens' data literacy (United Nations Secretary-General's High-level Panel on Digital Cooperation, 2019; United Nations Educational, Scientific and Cultural Organization, 2018). These challenges include regulatory changes; public concern over the effects of social media; repeated data breaches; and growing inequities in the uses of digital media.

The analyses presented here relate to these challenges and are based on a nationally representative survey of UK citizen data literacy carried out by 'Me and My Big Data' in 2019. 'Me and My Big Data' is a University of Liverpool, Glasgow University and Sheffield Hallam University collaborative research project funded by the Nuffield Foundation that seeks to understand the levels of and variations in UK citizens' data literacy, and to develop policy and educational materials to support improving it.[1] For more information about the project see bit.ly/meandmybigdata.

In this article, we present the preliminary results of the first two research stages of the 'Me and My Big Data' research project: (1) a systematic literature review, and (2) a nationally representative

Figure 6.1. Visual representation of Me and My Big Data Project




Source: Me and My Big Data Project

survey of UK citizens' data literacy. We begin by introducing our new data literacy framework, called 'Data Citizenship'. This framework is based on a systematic review of literature that identified the current gaps in theorizing data literacy. The Data Citizenship framework focuses on three domains: Data Thinking (citizens' critical understanding of data), Data Doing (people's everyday engagements with data) and Data Participation (people's proactive engagement with data and their networks of literacy).

Following, using survey data from 1,542 responses, we provide new insights into UK citizens' data practices (security measures, verification of data, trust in online sources) and their understanding of the use of their own data. We then analyse these insights through our theoretical framework Data Citizenship. In our findings section, we reflect on some 'Me and My Big Data' survey outcomes. Our analysis reveals some contradictions between how citizens *think about* the truthfulness of online information (e.g. online news) and what they *do to verify* its accuracy (e.g. fact-checking). We thus suggest that these contradictions might be related to citizens' limited data literacy levels. We conclude our article with a set of recommendations for practical implementation of Data Citizenship.

## Conceptualizing Data Citizenship

To get a better understanding of what work has been conducted on media, digital and data literacies, we mapped debates in this field so far. Our systematic review of academic literature, news articles, government/policy documents and NGO reports revealed that data literacy skills primarily fall into two categories: citizen's practical management of their data and critical thinking skills about data (though to a much lesser extent). We have categorized these skills and labelled them as two domains: Data Doing and Data Thinking. Our analysis also revealed a third and less discussed area of 'data literacy' practice, concerned with citizens' proactive participation in data society and their 'networks of literacy'. Accounting for people's complex data-related engagements with their families, friends and communities, we developed the concept of 'networks of literacies'. Networks of literacies describe how people engage with others, where and with which media, to gain understanding or skills to engage with media in a way that fits them. The third area of Data Citizenship is called 'Data Participation'. We propose an open-ended theoretical framework in the hope of starting cross-disciplinary conversations on the value of the different areas of citizens' data expertise(see Figure 6.2 below).

Data Citizenship is defined as a framework that emphasizes the multi-layered and networked nature of citizens' interactions with data society. Data Citizenship views citizens not only as passive receivers of and responders to society's datafication, but as proactive participants and co-creators of data society as well as its norms and regulations. Through Data Citizenship we aim to empower citizens, educators, researchers and policy-makers to engage in both individual and collective critical inquiry into citizens' data roles, abilities and responsibilities.

### Data Doing

Data Doing is defined as a set of skills essential for conscious and informed digital participation in the data society. Data Doing builds on the prior scholarly understanding of data management and extends it by adding skills which specifically respond to challenges associated with use of information (e.g. accessing and assessing news). Data Doing emphasizes the importance of citizens' abilities to manage data in an ethical and critical manner (e.g. citing the original data source when sharing information on social media). Through 'data doing' we aim to highlight the importance of practical and ethical data management, creation and deletion, which we find an important aspect that has not been properly covered in the literature so far. An example of Data Doing behaviours might include sharing information on social media. We have identified nine practices when examining citizens Data Doing skills (see Table 6.1).

### Data Thinking

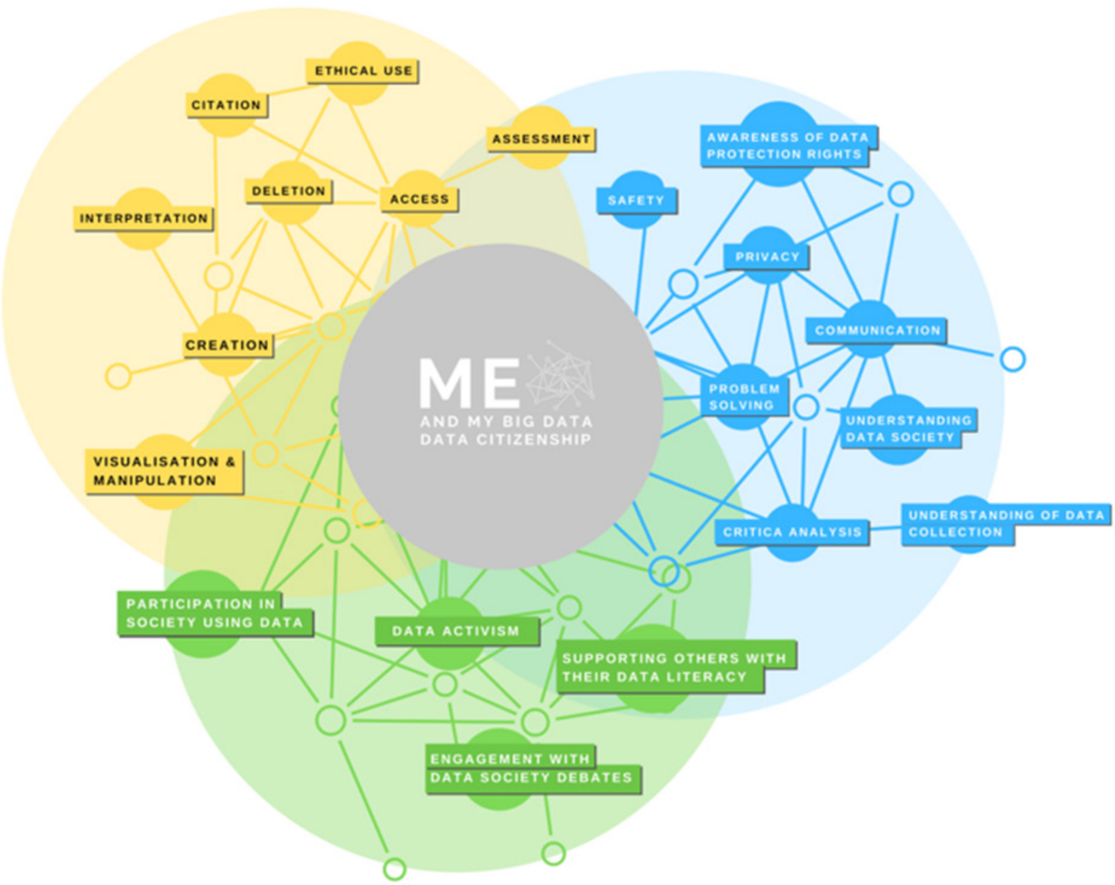
In the second area of Data Citizenship expertise, Data Thinking, we highlight the importance of citizens' critical thinking abilities when dealing with data in their everyday lives. We argue that data-literate citizens should use their critical skills as they view and analyse the world through data.

Table 6.1. Nine areas of expertise of Data Doing

| Data Doing | |
|---|---|
| **Area of expertise** | **Description** |
| Accessing | The ability to search for, identify and access services, websites and data |
| Assessing | The ability to evaluate data quality and credibility (e.g. fact-checking, checking sources of social media posts) |
| Interpretation | The ability to interpret different data formats (e.g. graphs, infographics, interface features) |
| Data creation | The ability to create data in different formats (e.g. creation of a blog post, social media post/ hashtag, presentation) |
| Data citation | The ability to cite data sources (e.g. text references, image sources) |
| Data management | The ability to store, encrypt and manage data in a safe and secure way |
| Data visualization and manipulation | The ability to represent data in a visual way (e.g. using infographics) |
| Data deletion | The ability to delete data (e.g. deletion of cookies, browsing history) |
| Ethical use | The ability to use data ethically (e.g. not sharing someone's else personal data, not manipulating or misquoting data, anonymizing people's identity) |

We emphasize the importance of thinking that includes various practices around data (see Table 6.2) such as: being aware, questioning, examining, verifying and understanding. We argue that data citizens should be provided with skills to use data in their daily lives in a way that makes sense to the context of their individual and community life. Data Thinking activities might involve sourcing,

Figure 6.2. Visual representation of the Data Citizenship framework and its three areas of expertise: Data Thinking, Data Doing and Data Participation




Note: The green circle represents Data Participation; the blue circle represents Data Thinking; and the yellow Circle represents Data Doing.

Source: Me and My Big Data Project

verifying and critically evaluating data while forming an argument or communicating. Data Thinking aims to highlight the importance of citizens' awareness of data safety, privacy and their data protection rights both as individuals and part of communities.

### Data Participation

The third domain of our Data Citizenship framework, Data Participation, outlines the importance of citizens' proactive engagement with data society. Data Participation incorporates and extends the domains of 'data thinking' and 'data doing'. We propose that empowered citizens use their existing skills to actively participate in the data society by seeking opportunities to exercise their rights as well as to contribute to and shape their collective data experiences. Examples of Data Participation citizens might include persons who actively contribute to online forums, use open data for the benefit of their community, help others to set up a secure password, engage in privacy and/or debates, or take steps to protect their personal information.[See Table 6.3]

Table 6.2. Eight areas of expertise associated with Data Thinking

| Data Thinking | |
|---|---|
| **Area of expertise** | **Description** |
| Awareness of data protection rights | Being aware of local (UK) or regional (EU General Data Protection Regulation) data protection laws |
| Communicating with data | The ability to refer to, contextualize and use data for communication (e.g. providing evidence to validate an argument, on social media, in research) |
| Critical data analysis (e.g. data bias, cultural contexts) | The ability to consider, examine and discuss data bias, methodological errors, inaccurate data visualization |
| Data safety (e.g. skills to manage and control 'digital traces') | The ability to consider and implement data protective steps when using data (e.g. using private browsing features or more secure browsers, using more secure search engines, strong passwords) |
| Privacy | The ability to consider and implement privacy-protective behaviour when using data (e.g. using avatars, deleting tweets every couple of weeks) |
| Problem-solving using data | The ability to search for, identify and use data to solve problems (e.g. open data projects) |
| Understanding data society (impact, procedures and power dynamics) | The ability to understand the way the data economy works (e.g. how platforms are funded, what cookies are, broadly what algorithms do) |
| Understanding of data collection | The ability to understand the different data-collection practices of different institutions (e.g. governments, advertising organizations, data brokers) as well as different databases (e.g. National Health Service, local government voter registers, data brokers) |

Table 6.3. Four areas of expertise associated with Data Participation

| Data Participation | |
|---|---|
| **Area of expertise** | **Description** |
| Participating in society using data | The ability to use data for societal participation and civic action (e.g. citizen-led campaigns, using online government services such as the National Health Service, Her Majesty's Revenue and Customs) |
| Engagement with data society debates | The ability to engage in debates on data protection rights or/and Internet governance (e.g. engagement in privacy or/and debates) |
| Data activism (proactive engagement with data structures, including data hacking) | The ability to take proactive steps to protect individuals' and collective privacy and well-being in the data society (e.g. reporting inappropriate or 'fake' content online, blocking or mitigating data collection using apps such as Ad Blocker)<br>The ability to collectively promote and exercise digital rights (e.g. using obfuscation or collective group uses of social media accounts). The ability to object/resist/modify the hegemonic way of using data services |
| Supporting others with their data literacy | The ability to help others with their data literacy (e.g. helping others with their privacy settings, explaining to people what clicking 'consent' means) |

## Me and My Big Data survey design and analysis

In 2019, our Me and My Big Data project designed and carried out a nationally representative survey of UK citizens’ data literacy. Our Data Citizenship theoretical framework informed the survey design and it’s three domains: Data Thinking, Data Doing and Data Participation.

The survey quota sample was sourced from UK Geographics[2] and broken into sampling points using Census 2011 Output Areas. In total, 125 sampling points were used to achieve a maximum of n = 1,542 interviews. These points were selected to be a representative cross-section of UK addresses and reflective of the UK population by age, gender, household socio-economic group and urbanity. The data were collected August–September 2019. Analysis of the data was carried out in three stages.

### Stage 1: Identification of digital media users

Our analysis (latent class analysis) revealed five types of digital media users identified by their media use patterns:

1. **Extensive political users (10 per cent of users)** – High probability of engaging in all forms of digital media use, including political action and communication.
2. **Extensive users (20 per cent of users) –** High probability of engaging in all forms of digital media use except political action and communication.
3. **Social and media users (17 per cent of users)** – High likelihood of engaging with social media (social networking sites) and entertainment media (e.g. Netflix and YouTube).
4. **General users (no social media) (31 per cent of users)** – Lower likelihood of engaging in most digital media forms but not social networking sites.
5. **Limited users (22 per cent of users)** – Limited engagement with all forms of digital media.

In Table 6.4 we present our digital media user types and their demographics such as age, education, children and home ownership.

### Stage 2: Comparison of behaviours and opinions against user types

The purpose of the second stage of our analysis was to examine our survey questions and responses in relation to different user groups. To this end, we modelled user types against their demographics using multinomial regression (extensive political users as the baseline) as well as individual cross-tabulations.

### Stage 3: Multiple correspondence analysis

In the third stage, we used multiple correspondence analysis to explore the mapping of our framework questions onto user types.

## Survey findings

The analysis presented in this article illustrates a small selection of our preliminary findings. The findings are categorized in line with our Data Citizenship frameworks conceptual domains: Data Thinking, Data Doing and Data Participation.

### Data Thinking: People’s understanding of the data society

In the Data Thinking domain, we aimed to explore citizens' attitudes towards data collection, selling, targeting and tracking processes and their trust in the organizations and companies that handle their personal data. Overall our results indicate that all groups of users are uncomfortable with sharing their personal information. For example, most people questioned do not feel comfortable with being tracked online (90 per cent), having their personal data sold (95 per cent) or having their data used to influence their opinions or choices (90 per cent). Overall, it seems that most people feel uncomfortable with the selling and tracking of their data, but also feel that they have no choice but to share personal data to participate in digital society. For example, 65 per cent indicate that they do not want to share their data with companies but have no choice if they want to access their services (e.g. Facebook, Twitter, Google).

These findings go along with the fact that people also seem to feel a sense of powerlessness and resignation in the way they can perceive and

Table 6.4. 'Me and My Big Data' digital media user types and their demographics

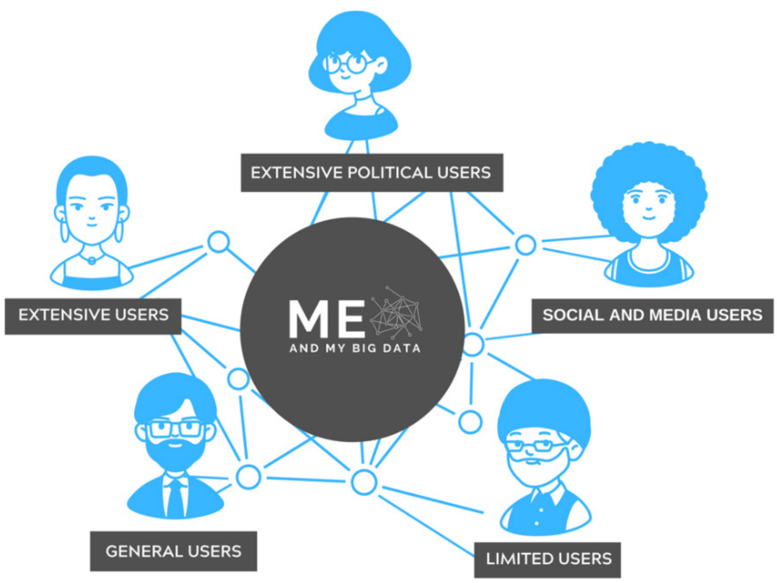
| Type of user/ demographic | Age | Education | Children | Home |
|---|---|---|---|---|
| Extensive political | Likely to be 16–44 | Very likely to have a first-level university degree | Likely to have children in the home (1–2) | Bought a home on a mortgage |
| Extensive | Likely to be 16–44 | Very likely to have a first-level University degree or higher | Likely to have children in the home (1–2) | Buying home on a mortgage or privately renting a property |
| Social and media | Likely to be 16–24 | Likely to have a General Certificate of Secondary Education* including Maths and English | Likely to have children in the home or to be living at parents' home | Likely to live in rented accommodation (including renting from Local Authority, Social Housing or private landlord) |
| General | Likely to be 45–64 | Likely to have a first-level university degree | Unlikely to have children in the home | Bought a home on a mortgage |
| Limited | Likely to be 55 and over | May have GCSE including Maths and English | Unlikely to have children in the home | Likely to own outright or to be renting from Local Authority |

* In the UK, the General Certificate of Secondary Education is an academic qualification generally taken in a number of subjects by pupils in secondary education in England, Wales and Northern Ireland.

interact with their privacy settings. For example, just over 50 per cent of all users indicated that there is no point in changing their privacy settings because companies will be able to get around these settings anyway. Moreover, a majority of all users (70 per cent) believe that online companies make it deliberately difficult for people to change their privacy settings in the first place.

Our analysis revealed that there is a distinction between citizens' acceptance of receiving data-driven personalization and their views on being tracked online. As noted above, most feel uncomfortable with being tracked online, having their personal data sold or having their data used to influence their opinions or choices. However, there is a more accepting attitude towards data-driven personalization of apps or websites (up to 60 per cent) and tailoring of prices for products or services. These findings indicate that citizens have a limited understanding of the online economy and how various platforms and services are funded. This lack of critical understanding prevents them from making connections between data-collection processes and the personalization of their experiences (Carmi, 2020). In particular, it prevents

Figure 6.3. Visual representation of Me and My Big Data Digital Media Users




Source: Me and My Big Data Project

them from understanding how these link to their different impacts on society and citizens.

### Data Doing: Reaching beyond one's echo chamber

To better understand citizens' data literacy, we then combined their critical thinking when sourcing information (Data Thinking) and the steps they take to diversify and verify their information sources (Data Doing).

Our results suggest that many citizens have concerns over the accuracy and trustworthiness of information they find online. For example, 60 per cent believed that only some of the information they find online is truthful. However, citizens seem to be taking very limited steps to verify the results of their online searches. When asked about what (if any) steps they take to check the factualness of their online searches, only 37 per cent check if the source of the information is trustworthy; 30 per cent check to see if the same information appears anywhere else, and only 30 per cent take time to think about whether the content is true.

Similar contradictions between citizens' beliefs and their actions were noted in the context of their news consumption. For example, 44 per cent indicated that they do not trust the news that they consume. However, there is little evidence that they take steps to verify or diversify their news sources. For example, 53 per cent said that they mainly read, watch or listen to news sources which seem to share their values and opinions. Only 24 per cent try to view news websites with a different political perspective.

We have also noted some striking differences among our user groups and the actions they take to reach beyond their informational echo chamber. For instance, nearly all of the social and media users (95 per cent) make no effort to view news websites which present political perspectives different from their own. This group is also most likely to trust the content that their friends post on social media (55 per cent), with only 30 per cent making an effort to view posts outside their social media echo chamber. In contrast, extensive political users (40 per cent) are among the most likely to check, verify and diversify their online information sources. These findings indicate that those with higher levels of Data Thinking are also more proactive in their Data Doing domain.

### Data participation: supporting others' data literacy

To understand citizens' levels of data participation, we asked questions related to their proactive behaviours around data in their everyday lives, at both individual and community level. For example, we were interested if citizens help others with their data literacy (e.g. changing passwords, fact-checking).

Our results suggest that citizens who present themselves as confident 'data thinkers' and 'data doers' (such as extensive political users and extensive users) are more likely to be active data participants. For example, extensive users are most likely to help others with their data literacy: 47 per cent have explained or shown others how to stay safe online (for example by showing them how to change their privacy settings); 65 per cent have helped others with data or security in some way; 43 per cent have encouraged or shown others how to fact-check things online.

In contrast, some of the lowest scores in Data Participation behaviours were noted among social and media users. Members of this group seem to be among some of the most passive data citizens. Social and media users – most of whom are 16–24 years old, from a lower economic class and lack further or higher education – are most likely to trust what their friends post on social media (55 per cent) and thus less likely to fact-check or verify sources online. For example, 70 per cent of social and media users reported that they make no effort to view social media posts that come from a political perspective different from their own. Our analysis also showed that social and media users and limited users are among those less likely to actively help others with their data safety and privacy settings (10 per cent) or encourage others to fact-check (8 per cent).

These findings demystify the notion of 'digital natives' (Prensky, 2009), the assumption that young people born in the digital era will naturally adopt digital literacy. Contrary to this, our findings show that age, education and socio-economic status have a huge effect on people's understanding, doing and participating and thus their management of information.

## Discussion

So what have we learned about UK citizens' data literacy? Our analysis reveals a number of contradictions in the ways citizens think, manage and act regarding their data. First, we noted citizens contradictory views on 'not wanting to be tracked' but 'wanting to receive personalized online services'. It is possible that in line with prior research (Ofcom, 2018), many citizens in the UK have limited understanding of the online ecosystem and economy: how and when their personal data is collected, analysed and shared with third parties. Additionally, it might be argued that citizens have no choice but to balance the negative consequences of 'tracking' (e.g. surveillance, lack of privacy, trading of their data) and the perceived positive aspects of 'personalization' and free services/content. There also seems to be a general sense of distrust towards online companies, news outlets and social media companies. In our data, citizens appear to be sceptical of potential misuse of data but engage in mainly passive ways. While many citizens in the UK recognize problems related to the accuracy and validity of online information and content, they do very little to check or verify it.

## Conclusion

The aim of this article was to present the initial stages of a UK-based research project called 'Me and My Big Data'. The aim of this research project was to examine UK citizens' data literacy level and provide new insights into their variations. To this end, our team developed a new theoretical framework called Data Citizenship. The Data Citizenship framework and its three domains (Data Doing, Data Thinking and Data Participation) were then used to design a national survey of citizens' data literacy.

Our 'Me and My Big Data' survey found that levels of data literacy vary across the three domains of the Data Citizenship framework, especially depending on the different user types we have identified. The preliminary findings presented in this article shed light on some of the nuances of citizens' data literacy. In particular, we discussed citizens' conflicting attitudes towards online tracking and personalization (Data Thinking), their limited willingness to verify and fact-check online information (Data Doing), and the limited evidence that citizens help each other with data literacy (Data Participation). We show how the way people think, do and participate depend on their age, education and socio-economic condition, findings that have been consistent with our previous research.[3] However, our findings also contribute in several ways to existing debates on the understanding of citizens' data literacy and provide a basis for future research in this area. To this end, we provide several recommendations on how Data Citizenship could be taken forward in research and practice.

## Data Citizenship in practice: Recommendations

The Data Citizenship framework allowed us to ground our work in prior research and provide a useful structure for our survey design and its analysis. The three Data Citizenship domains helped us better understand the granular and interconnected nature of citizens' data literacy. As illustrated in this article, citizens' data literacy skills, critical thinking abilities and behaviours overlap across the three domains of Data Thinking, Data Doing and Data Participation. Although Data Citizenship provides a structure, it is really about the insights that might emerge in between the theoretical domains. We hope that future critiques, interpretations and applications of Data Citizenship will help to better understand and enhance citizens' abilities to participate in data society, in ways that benefit them and their communities.

We propose that our Data Citizenship framework might provide researchers, policy-makers and practitioners with a robust and flexible framework to support their theoretical and practical data literacy interventions. Below we present our initial recommendations for the use of Data Citizenship in research and practice.

### 1. Data Citizenship as a strategy for civic engagement and awareness-raising

Data Citizenship can be used to underpin the design and implementation of data awareness and advocacy programmes. Our framework may provide different stakeholders (e.g. educators, activists, NGOs, organizations and policy-makers) with a set of tools that could enrich the design and implementation of their civic engagement programmes and any related advocacy efforts.

For example, activists and NGOs might choose to use and refine the framework and the three domains to suit their different geopolitical and cultural contexts and groups. Data Citizenship could be used to highlight citizens' voices and use them to influence strategic decisions on data regulation and privacy. It is also possible that, in practice, implementation of Data Citizenship in civic engagement programmes could lead to co-creation of more meaningful, holistic and citizen-centred data education, policy-making interventions and data society governance.

### 2. Data Citizenship as a tool for data literacy assessment

The three domains of Data Thinking, Data Doing and Data Participation can serve as a baseline assessment of data literacy levels. Using the three domains and skills (presented in Tables 6.1, 6.2 and 6.3), digital inclusion practitioners can evaluate citizens' data literacy levels and identify any gaps in the ways they interact with and think about data.

### 3. Data Citizenship as a tool for participatory learning

We believe that Data Citizenship provides an accessible and open-ended outline which can further be expanded and grounded in a contextualized learning setting. Our framework could therefore be used as a practical tool for making interventions in people's networks of literacy, meaning community-focused workshops. Practitioners might choose to print our Data Citizenship graphics and tables in order to begin conversations about citizens' attitudes towards data and data society. Data Citizenship domains can be used separately to focus on individual skill sets (e.g. citizens' ability to fact-check) or societal problems related to data society (e.g. data-driven political campaigns and digital human rights).

### 4. Data Citizenship in research design

Data Citizenship can be used to design and implement research activities. As already discussed, Data Citizenship is grounded in a systematic review of literature focused on data literacy. As presented in this article, we used Data Citizenship to design our survey and to analyse it. We hope that other researchers might find this framework useful in their future examinations of citizens' data literacy.

The above recommendations are based on the first stages of our research project: a systematic literature review and nationally representative survey of citizens' data literacy levels in the UK.[4] It is important to note that these recommendations will be further tested and refined in the next stages of our project, which will include workshops with citizens and policy-makers in 2020. The results of the workshops will further inform the design of data literacy educational materials which will be available on our website (bit.ly/meandmybigdata) in 2021.

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# #eSkills4Policymakers: From policy recommendations to policy action – Training policy-makers on gender equality in ICT policy formulation

*By Ingrid Brudvig, Nanjira Sambuli & Dhanaraj Thakur*

## Introduction

The objective of this paper is to demonstrate why bridging the digital gender gap relies on gender-responsive information and communication technology (ICT) policy. This entails expanding the digital capabilities of policy-makers to better understand the barriers to Internet access, and equipping them with the tools to promote more inclusive public policy. The basis is informed by experiences and lessons learned from a series of #eSkills4PolicyMakers workshops. This paper will situate the need for digital skills training and capacity development programmes for policy-makers, and assess key takeaways from three #eSkills4PolicyMakers workshops held in Maputo, Accra and Jakarta in 2019–2020, which sensitized policy-makers on closing the digital gender divide through gender-responsive ICT policy.

In this paper, we outline steps that can be taken to make policies more gender-responsive, starting with educating policy-makers, collecting relevant data and evidence to inform policy and developing gender-responsive ICT policy based on participatory processes with women involved in policy decision-making. The paper argues that countries must first commit to collecting sex-disaggregated ICT data, describing the cases of several countries that have taken steps to integrate gender and ICT data into their national census and statistical outputs. This paper goes on to argue that any policy or project to get more people online will only reinforce digital inequalities unless it specifically targets the gender gap (World Wide Web Foundation, 2017). It will conclude by describing the key learnings from #eSkills4PolicyMakers workshops and assess how this digital skills development approach impacts perceptions of gender equality in ICT policy formulation. These workshops are central to engaging government stakeholders on underlying perceptions and assumptions about gender, addressing the key factors contributing to the global ICT gender gap, and training policy-makers on integrating gender equality in ICT policy formulation through 'gender-responsive ICT policy'.

In 2019 and early 2020, the World Wide Web Foundation and Alliance for Affordable Internet (A4AI) facilitated a series of regional #eSkills4PolicyMakers[1] workshops with ICT and education sector policy-makers from Eastern and Southern Africa, anglophone West Africa and the Asia-Pacific region to support government actors in reformulating their policies to ensure equal, affordable and meaningful access to the Internet for women and girls. The interactive, hands-on workshops included an equal number of male and female participants and focused on the intersections of ICT, gender and education policies and respective line ministries and agencies. The aim was to explore with invited government and regional body representatives how to mainstream gender-responsiveness into ICT policies and investments. The workshops took policy recommendations on bridging the digital gender divide and repurposed them into digital skilling for policy-makers, in line with their objectives and mandates.

Based on the research initiatives of global and regional institutions such as the International Telecommunication Union (ITU), GSM Association, A4AI and the World Wide Web Foundation's Women's Rights Online, there is a global consensus that sex-disaggregated data is critical to monitoring the extent of the ICT gender gap, and to informing gender-responsive technology policy-making. In addition to its value in informing policy-making, sex-disaggregated data is critical to monitoring progress towards achieving the Sustainable Development Goals (SDGs) on women and technology, particularly SDG 5c (empowering women through technology) and SDG 9c (universal, affordable Internet access). Thus, the first step to creating a more gender equitable system of digital transformation is making sure that all ICT, broadband and digital education policies have bold gender equality targets backed by the strategies, plans and budget necessary to deliver on them. Data and evidence are essential to inform the development of targets, plans and gender-responsive ICT strategies and policies.

Internet access has the power to expand social and economic opportunities, civic participation and activism, cultural understanding and the arts. A global gender gap in Internet access reinforces inequalities in society and limits digital opportunity. This paper argues that the existence of the digital gender gap is fundamentally a result of policy failure. While a few countries have taken some steps in their policies to address the gap in access and use, these are insufficient and much work remains to be done. In addition to developing gender-responsive policies (as this paper will describe in detail), it is critical that women are included in the policy-making process. Policy designed for all citizens – and particularly policy focused on affecting women – should be designed with women, and governments must work to secure women's participation in the policy-making process. Across the globe, women's organizations have made significant contributions to incorporating gender perspectives in policy across various sectors such as health, education and the environment. Unfortunately, this is not the case for ICT policy, where women's voices are largely left out of the policy-making process. Better broadband policies offer a clear path to improving women's Internet access and use, and to moving towards universal digital access and digital skills development goals.

Many efforts to address the gender gap in ICT and Internet access and use may include efforts at improving the digital skills of women and girls. However, we note that often policy-makers themselves – and other decision-makers in government, industry and civil society – lack the requisite skills and knowledge to effect meaningful policy change to lower the gender gap in ICT and Internet access and use (O'Donnell & Sweetman, 2018). This paper will describe the key learnings from #eSkills4PolicyMakers workshops and assess how this approach affected perceptions of gender-responsive policy among government participants. Programmes such as #eSkills4PolicyMakers are important educational initiatives to share knowledge and skills to help governments create policies that specifically target groups that are too often marginalized in the digital sphere. The workshops were designed to get policy-makers in ICT and education ministries and agencies to interact with the particulars of gender-responsive policy-making; the policy recommendations that shaped the workshops were repurposed as digital skilling for policy-makers. This approach also helped the policy-makers who participated confront their own perceptions around gender, and appreciate that the technical plans they may devise need to be assessed against sociocultural dimensions if they are to achieve the intended objectives.

## Defining the problem: Governments need sex-disaggregated ICT data to close the ICT gender gap

In 2015, world leaders adopted 17 SDGs as part of the 2030 Agenda for Sustainable Development. With respect to technology, the SDGs commit United Nations Member States to:

a) enhance the use of enabling technology, particularly ICT, to promote the empowerment of women (SDG 5b);
b) achieve universal, affordable Internet access in least developed countries by 2020 (SDG 9c);
c) ensure equal access to basic services [and] appropriate new technology for all women and men by 2030 (SDG 1.4)
d) substantially increase the number of youth and adults who have relevant skills, including ICT, technical and vocational skills, for employment, decent jobs and entrepreneurship (SDG 4.4); and
e) increase the proportion of schools with access to the Internet and computers for teaching and learning.

In 2019 just over half the world's population (53.6 per cent) was reported to be online (ITU, 2019). Women were the majority of the unconnected, with around 2 billion women estimated to be offline. This risks pushing unconnected women further to the margins of the global political economy and leaving men to reap the benefits of connectivity. Women were 17 per cent less likely to be online than men globally. Affordability is a major barrier to connectivity. Indeed, in low-income countries, the ICT gender gap is driven by the high cost of Internet connectivity, which remains unaffordable for many (A4AI, 2019; Rowntree, 2019). Globally, 58 per cent of men are online compared with 48 per cent of women; in developing countries this divide is even greater, and the global gap has increased since 2013 (ITU, 2019), although it has narrowed in many individual countries. In developing countries, the Internet user gender gap grew from 11 per cent in 2013 to 17 per cent in 2019. (ITU, 2019). Household survey research from 2015 across 10 cities in Africa, Asia and Latin America found that when looking at marginalized, urban communities, women were 50 per cent less likely to use the Internet than their male counterparts (World Wide Web Foundation, 2015). Women's exclusion from digital spaces is driven by the unaffordable cost of Internet services, limited digital skills education and training; a lack of relevant content and services; and threats to women's and girls' online safety (World Wide Web Foundation, 2015; Rowntree, 2019).

Governments have a long road ahead to achieve SDG commitments on ensuring equal, affordable access to new technology for all women and men by 2030, and leveraging ICTs to empower women. Better gender and ICT data would help to inform decision-making around gender equality in ICT by making policy-makers aware of the extent of the gender gap problem and helping them to better target their policy interventions at groups who are left behind. Currently, there is very little sex-disaggregated ICT data, and none of the major gender equality indices incorporate ICTs. This makes it nearly impossible for most countries to track progress in achieving the SDGs and connectivity targets, especially those related to gender. This is largely due to the fact that many countries do not conduct surveys of ICT use from which data disaggregated by gender and other social attributes can be derived. Much of the ICT data collected by governments come from administrative sources which are typically not broken down by sex/gender (such as subscription data). When sex-disaggregated ICT data is unavailable, the gender gap cannot be observed and therefore cannot be accounted for in policy-making. In 2019, just 24 countries in Africa and Asia submitted sex-disaggregated data on Internet access to the United Nations agency responsible for tracking this indicator, ITU.

Sex-disaggregated ICT data is critical to monitoring ICT gender gaps and informing gender-responsive technology policy-making. However, ensuring that such data is collected and available requires purposeful action, often supported by multi-stakeholder groups to create change. In Mozambique for instance, A4AI convened a broad group of stakeholders to advocate for the inclusion of sex-disaggregated ICT data in the national census.[2] Having conducted the census in 2017, Mozambique now has official census ICT data that can inform current and future ICT policy interventions. In general, many countries lack sex-disaggregated data, particularly for indicators relevant to the SDG goals mentioned above.

Closing the gender gap in ICT data is integral to successful gender-responsive ICT policy-making. As noted by the United Nations Conference on Trade and Development (2014), "Aggregate data collection masks gender differences, which implies that women's realities remain unrecorded and are ignored, not only in statistics but also in policy". SDG 17 commits governments to significantly increase the availability of high-quality, timely and reliable sex-disaggregated data. Technology has an increasingly vital role in achieving all SDG targets, facilitating access to information and public participation towards achieving national development goals. As the importance of access to and use of ICTs grows, so too does the need – and urgency – to collect sex-disaggregated data on whether and how women are accessing and using these technologies. Without this data, measuring and monitoring meaningful progress will remain impossible. The ITU Broadband Commission Working Group on Gender has called on countries to integrate gender into national ICT/broadband policies, and to initiate action plans to achieve gender equality in access to the Internet (United Nations Broadband Commission for Sustainable Development, 2017). The regular collection and analysis of data on gender and ICT is a vital prerequisite to achieve this.

## Formulating gender-responsive ICT policy

Internet access has the power to expand social and economic opportunities, civic participation and activism, cultural understanding and the arts. However, the global Internet user gender gap has grown from 11 per cent in 2013 to 17 per cent in 2019 (ITU, 2019). A global gender gap in Internet access reinforces inequalities in society and limits digital opportunity. There is a need to both prioritize gender equality issues at the highest levels of policy-making and link ICT policies to existing gender and development policies to ensure that governments and policy-makers consider the real potential of broadband as an enabler for development.

Bold steps are needed to accelerate connectivity among women, the poor and other marginalized populations, as we cannot achieve universal access with up to half of the world's population being left behind. Overcoming the barriers to Internet access – including income and gender inequalities – will require policies designed with these populations in mind. Market forces alone cannot connect and are not connecting everyone; free or subsidized public access in tandem with digital education will be critical to enabling connectivity for populations left behind (A4AI, 2019).

Integrating gender perspectives in ICT/telecommunications policy means fully understanding how women and men have been socialized differently and, consequently, understanding the disparate impacts of policy on the different genders (A4AI, 2015). Women, for instance, have differential access to the Internet due to factors such as income, education level and social norms, which need to be taken into account when developing inclusive policies (World Wide Web Foundation, 2015). It is also important to note that women are not a homogeneous group, and policy should consider the experience of women from different socio-economic groups, ethnicity, age, sexual orientation, etc.

A gender-responsive ICT policy, therefore, is one that equally considers and addresses the connectivity challenges and needs of all groups in society, and takes into particular consideration the unique challenges faced by women when it comes to accessing and using the Internet. In doing so, it helps to ensure equal outcomes for women and men.

Gender-responsive broadband planning is not just about making policy for women; rather, it is policy that ensures that all groups have equal opportunities to access and make use of broadband services. The more people that come online, the more a person is able to connect with friends and family, increase business opportunities, organize, and share knowledge and ideas. Thus, gender-responsive broadband policies will also be successful broadband policies (World Wide Web Foundation, 2017).

One study using data from 2016 reviewed 58 low- and middle-income countries and noted that only five had some policies that included efforts to increase access, training and use of the Internet by women and girls. However, even these countries lacked clear measurable targets to achieve these goals. In general, there was little evidence of most of these national policies being gender-responsive (World Wide Web Foundation, 2017).

Drawing on publicly available data from a more recent 2018 review of 61 low- and middle-income countries (almost the same set of countries as the 2016 study mentioned above), we find some improvement (A4AI, 2019). Out of these countries, 12 now have some policies that aim to address the digital gender gap and improve women's use of the Internet. However, very few have operationalized those policies with specific targets or clear programmes and funding to improve gender equality online. Even where these programmes exist they are often piecemeal efforts aimed at improving gender equality in access and use, and often focus on getting more women into the sector. For example, programmes such as CódigoX, which was previously active in Mexico, the 'Girls in ICT' portal run by the Sri Lankan regulator, and Ms. Geek Ghana all aim to increase women's and girls' participation in the ICT sector. The challenge is that these efforts often lack the long-term strategic cohesion which a gender-responsive broadband policy can provide.

## Policy-makers must REACT

To make ICT policies gender-responsive, governments need to factor in five interrelated areas: Rights, Education, Access, Content and Targets, otherwise summed up as REACT[3]

The REACT framework, in addition, should be accompanied by good policy practices such as:

- ensuring that all analysis conducted for the purposes of developing policies and plans integrates gender and gender considerations;
- involving gender advocates and experts in the policy and planning process from the start to ensure women-centric policy development;

### Figure 7.1. Digital gender equality

**Digital gender equality is about equality for ALL**

**Closing the ICT gender gap is also…**

*Good for business:*

"If mobile operators were to close existing gender gaps they could benefit from an additional US$140 billion in revenue by 2023" (Rowntree, 2019).

*The driver of a competitive digital economy:*

"Achieving gender equality is obviously necessary for economic reasons. Only those economies (that) have full access to all their talent (men and women) will remain competitive and will prosper".[4]

Source: Authors own 2020, unpublished

- allocating a percentage of available resources to support women-centred activities, including resources to promote and support women ICT entrepreneurs, digital literacy training for women and girls, and targeted public access and other projects to support access and use for women and girls; and
- establishing quotas to ensure the equal participation of women and other marginalized groups in all programmes supported by national policies and plans, especially rural and poor populations (A4AI, 2015).

### Figure 7.2. REACT framework

**Rights:** It is important that human rights offline are upheld in digital spaces as well as in ICT policy, and legislative and regulatory processes. The web must be a safe space for women and protect fundamental rights such as freedom of speech and privacy; it cannot serve as an empowering space unless everyone's rights are protected online.

**Education:** Education is the most powerful tool to close the digital gender gap. Digital skills ought to be included in primary and secondary school curricula in every country, with a specific focus on girls, who are often also left out of formal education. Steps must also be taken to eradicate the gender gap in access to higher and tertiary education by ensuring that women have equal access to tertiary education opportunities. Furthermore, educating policy-makers is an important consideration, and one that has been the cornerstone of the #eSkills4PolicyMakers initiative.

**Access:** Affordability remains a major obstacle to universal Internet access across the globe; women, on average, earn less than men, resulting in a higher cost to connect. Countries must adopt and work towards a more ambitious 'one for two' affordability target – 1GB of data monthly for less than 2 per cent of monthly income. This standard has been adopted by the United Nations Broadband Commission for Sustainable Development as a standard definition of Internet affordability. Public access programmes that offer free or subsidized ways to connect in public spaces can also enable those who might not be able to afford a connection, even once prices have reduced, to come online. Countries should also prioritize 'meaningful connectivity', defined by A4AI (2019) as Internet connectivity that has met the following baseline criteria: a) sufficient download speed to access multimedia Internet services; b) an adequate device to both produce and consume content (not just mobile-only access, but also laptop or desktop); enough data; and a frequent connection.[5]

**Content:** Content on the web must be relevant for people to use it. Governments can play an important role here both by delivering vital services online and by ensuring content (public information) is available in local languages. As content and service delivery providers, governments must ensure that critical government content relevant to women, including information on sexual and reproductive health, legal rights and digital financial services, is readily available online in local languages. It is also imperative to encourage women and girls to be content creators themselves, which is closely related to imparting digital skills and confidence in accessing and using the web.

**Targets:** Every country ought to update their connectivity targets as mandated by the SDGs, including clearly laying out how they will close the gender gap and regularly publishing data on progress towards these targets in open formats.

Source: Authors own 2020, unpublished

## Lessons from #eSkills4Policymakers workshops in Eastern and Southern Africa, West Africa and the Asia-Pacific region on creating gender-responsive ICT policies

Many efforts to address the gender gap in ICT and Internet access and use may include efforts at improving the digital skills of women and girls. However, policy-makers and other decision-makers in government, industry and civil society often lack the requisite digital development skills and knowledge to effect meaningful policy change to lower the gender gap in access and use. This section of the paper will describe the key takeaways from #eSkills4PolicyMakers workshops and lessons for developing and implementing gender-responsive ICT policy.

The workshops were designed to put into practice several policy recommendations devised by the World Wide Web Foundation's Women's Rights Online programme, as well as A4AI's affordability reports. This section assesses how this approach affected the perceptions of gender-responsive policy among government participants. Programmes such as #eSkills4PolicyMakers are important educational initiatives to share digital development knowledge and skills to help governments create policies that specifically target groups that are too often marginalized in the digital sphere.

Based on discussions and lessons learned from the #eSkills4PolicyMakers workshops, governments must do the following to prioritize gender-responsive policies in the fight for digital equality.

### 1. 'Never assume that technology is gender-neutral.' Define the problem and REACT

Many policies to connect the unconnected rest on the assumption that technology is gender-neutral. This is a fault in the very first stage of policy-making: problem definition. Case in point: blanket initiatives to 'connect everyone' with ICT infrastructure often fail to reach women and therefore the digital gender gap persists. For example, setting up ICT access points in public spaces that may be unsafe for women or out of range of their daily routes means the public Internet service will be underutilized.

A 'gender-neutral' approach to ICT policy-making is due to a lack of readily available official government data on the ICT gender gap, which masks the problem of the digital gender divide. For example, in countries across Latin America, aggregate statistics indicate a closed digital gender gap; however, when data analysis is disaggregated by demographic factors such as age, income, urban/rural location and ethnic group, the data reveal persistent gender gaps. This is revealed in *Women's Rights Online Report Cards* from Colombia (World Wide Web Foundation & Fundación Karisma, 2016) and Mexico (Derechos Digitales 2017), for example.

Additionally, gender advocates are rarely consulted as key stakeholders in ICT policy-making spaces. It is important to involve gender advocates in ICT policy-making processes to review if plans have factored in women's specific concerns across regions. For example, if infrastructure is deployed in a rural area or if public Wi-Fi is installed in a town centre, a crucial consideration would be whether it is within usable range for women during their routine economic activities (e.g. in the market), or care work (at home). Failure to consider gender perspectives means that policies are often unsuccessful in connecting women and the poorest. Gender perspectives are also important to digital skills interventions, in addressing the disparities in ICT skills and capabilities, and in interventions to deliver applications, services and content that are relevant to women's challenges and needs. As one workshop participant highlighted, "Never assume that access means they will come".

The digital gender divide is a political, economic, social and even 'technical' problem with many possible responses that may have different outcomes in different communities. To identify and understand the specific problems to be addressed by gender-responsive policy in the digital sector, stakeholders must first collect gender and ICT data, consult a variety of stakeholders and REACT – that is, assess how the problem can be addressed by focusing on rights, education, access, content and targets (World Wide Web Foundation, 2017). Each element of REACT must be considered in any policy intervention, avoiding siloed interventions. For example, an initiative to bring access to rural areas through network deployment must also consider the important roles of digital skills and education,

Figure 7.3. Tackling gender perceptions

| **Tackling gender perceptions to understand and address the digital gender divide** |
|---|
| The #eSkills4PolicyMakers workshops approach also affected government stakeholders' perceptions of gender in formulating policy. For example, in the Ghana workshop, participants engaged in an open discussion to uncover both personal perceptions of gender and deep-seated ideas about culture to understand their influence on policy-making. In the Jakarta workshop, participants discussed the links between systemic gender-based discrimination, institutional biases and how these translate into interpersonal relationships. This exercise helped participants think about gender bias more generally before getting into the specific ICT policy process and how gender should be considered throughout. Policy-makers who participated in these workshops established that every problem has a social, economic, political and cultural dimension that needs to be assessed and addressed in gender-responsive policy. As a result, the groups were able to engage in discussion on the topic, bringing together different country perspectives on how problems can have multiple underlying layers that need to be analysed down to the root causes in order to secure the right policy options that speak to closing the gender gap. |

Source: Authors own 2020, unpublished

relevant content and services and digital rights (including online safety and data protection).

## 2. Gender-responsive policy is not a zero-sum game

A widely held perception is that gender-responsive policy-making implies de-prioritizing other issues (like ICT infrastructure), requires additional budget, or neglects men and boys. These are all false. In fact, gender-responsive policy-making is an opportunity to open the 'rigid' approaches to policy and to cater to groups left behind by delivering services to the public and reaching the unconnected – who are disproportionately female. To achieve the SDGs overall, we will need to centre those most left behind, including women. Closing the digital gender divide will be the rising tide that lifts all boats. Addressing gender equality in policy is not a patchwork fix or a one-off consideration. It is a continuous exercise to ensure that down the line, no one is left behind. As such, gender-responsive policy-making requires continual assessment, as well as monitoring and evaluation of the impact of policy measures on different groups in society.

Gender considerations need not be a stand-alone or separate process. Instead, stakeholders should ensure that all analysis conducted for the purposes of developing policies and plans – from network deployment analysis to universal access strategies and priorities – is gender-responsive (A4AI, 2015). Policy options need to be holistic, addressing all aspects of the broader problem.

## 3. Embracing a multi-stakeholder approach is key for successful gender-responsive policy

To create successful ICT policies and strategies, stakeholders – including within government – must go beyond 'department' and 'knowledge' silos and ensure there is multi-stakeholder and public consultation for policy planning and implementation. This means engaging other actors within government, in the private sector (including small and medium-sized enterprises), and in civil society (including academia, cooperatives, consumer groups, associations and other citizen networks).

When designing possible policy approaches, factoring in perspectives and concerns from all stakeholders who will be affected by the policy is key to its success. For example, supplying ICT infrastructure or distributing hardware as part of ICT in education strategies must also address teacher training programmes. Supplying connectivity through fibre in rural areas must also assess if the network reaches women in the areas where they live and work. Governments should consider how incentives for private sector actors to deploy connectivity in rural areas may be pegged on connecting more women in order to serve a wider public.

While gender should be integrated from the beginning of policy formulation, it is often considered an 'afterthought' because of limited stakeholder engagement in defining the problem. This can be overcome by incorporating political, socio-cultural, economic, geographic and other relevant analyses and perspectives from a diverse range of stakeholders. Participants in the #eSkills4PolicyMakers workshops reflected on the benefits to be gained from sharing information and open data through online portals for multi-stakeholder collaboration across ICT, education and gender ministries, and with the public.

Policy should be designed for all citizens. For public policies to reach women, it is critical that they embrace multi-stakeholder engagement, undergirded by women's participation in the policy-making process. Multi-stakeholder dialogues and consultations are important processes to impact the perceptions of gender-responsive policy among government stakeholders and policy-makers. For example, as a result of the multi-stakeholder #eSkills4PolicyMakers workshop in Maputo with policy-makers from Eastern and Southern Africa, the Uganda Communications Commission committed to carrying out a nationally representative household survey on gender and ICT in partnership with the World Wide Web Foundation. The resulting data will inform the development of gender-responsive ICT policies as a cornerstone towards closing the digital divide in Uganda.

## Conclusion

This paper argues that the existence of the digital gender gap is fundamentally a result of limited data and stakeholder knowledge about ICT gender gaps, leading to limited acknowledgement of gender considerations more broadly in ICT policy design. While a few countries have taken steps in their policies to address the gaps in access and use, these are insufficient and much work remains to be done by all countries.

Better broadband policies offer a clear path to improving women's Internet access and use, and to moving towards universal access goals. In this paper, we have defined gender-responsive ICT policy and outlined steps that can be taken to integrate this important approach to policies. Developing gender-responsive ICT policies starts with enhancing the digital skills of policy-makers through forums and trainings such as #eSkills4PolicyMakers, facilitated by gender and ICT experts. The process of educating policy-makers on gender equality in ICT policy formulation also requires collecting relevant sex-disaggregated data and evidence to make the case and to inform policy, as well as developing gender-responsive ICT policy based on participatory processes, with women included in decision-making. Furthermore, as this paper has demonstrated, gender-responsive ICT policy-making is not a zero-sum game, and gender should not be added into policy as an afterthought. Instead, policy-makers should take advantage of how centring those left behind through gender-responsive ICT policy can benefit all and lead to better public policy for all.

To bridge the digital gender gap we need policy-makers who understand the barriers to access and have the tools to address gender equality in ICT policy formulation in order to promote more inclusive public policy. Programmes like #eSkills4PolicyMakers are important multi-stakeholder spaces to share knowledge and skills to help governments create policies that specifically target groups that are too often marginalized in the digital sphere. It is now time for governments to take responsibility and immediate action to maximize the benefits of the Internet and emerging technologies for all people.

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## Endnotes

[1] These workshops were a collaboration between the World Wide Web Foundation and the Alliance for Affordable Internet, with generous support from German Development Cooperation, under the EQUALS Global Partnership (Skills Coalition). Please visit www.equals.org for more information.

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# Tracking global gender gaps in information technology using online data

*By Florianne C.J. Verkroost, Ridhi Kashyap, Kiran Garimella, Ingmar Weber and Emilio Zagheni*

## Introduction

Despite the proliferation of information and communication technologies (ICTs), significant gender inequalities in the use of these technologies persist (Fatehkia et al., 2018). The International Telecommunication Union (ITU) (2017) estimates that around 200 million fewer women are online than men. While gender gaps disfavouring women in Internet access and basic digital skills can be sizeable, especially in less developed countries, gender gaps in high-level digital skills, such as those required to work in jobs in the information technology (IT) sector, are thought to be even larger in most countries (Borgonovi et al., 2018). For example, a recent report showed that only 16 per cent of the talent in artificial intelligence, an area of significant projected growth in the IT sector, is female (Roca, 2019). These gender gaps are especially important to measure and understand in the context of increasing digitization of labour markets, and to ensure the continued economic empowerment of women as envisaged in Sustainable Development Goal 5 on gender equality (Davaki, 2018). Furthermore, with the increasing diversification and specialization of jobs in the IT sector, it is important to understand the variation in gender gaps across different subdomains within the sector.

This article contributes to understanding global variations in gender gaps in IT industries by drawing on a novel source of online data – specifically, aggregate, anonymous data from the advertising platform of LinkedIn, the world's largest professional networking website. LinkedIn provides an advertising platform called LinkedIn Campaign Manager, which can be used to create and manage advertisements. Potential advertisers can specify their desired audience by providing targeting criteria such as gender, geography (e.g. country, city) and job industry. Based on these features, and before an advertisement is launched, LinkedIn provides an estimate of how many female and male LinkedIn users work in a particular industry per country, giving us an estimate of the supply of these industries.[1] By leveraging these aggregate data on the number of LinkedIn users, we examine the variation across countries in supply-side gender gaps in different subdomains of the IT sector (e.g. computer hardware or software, computer and network security, etc. as defined by LinkedIn Campaign Manager).

## Data and methods

### LinkedIn's advertising platform

LinkedIn is the world's biggest professional social networking website and currently has about 660 million users.[2] LinkedIn offers targeted advertising on the platform, whereby audiences can be targeted on demographic criteria (e.g. geography, gender, age group), as well as professional criteria (e.g. job seniority, company industry). Advertisers are shown approximations of the targeted audience size before launching advertisements. This aggregate count of users meeting a particular set of criteria essentially functions as a 'digital census' from a social research perspective, which enables us to collect data from a sizeable population that are available in real-time and capture about 17 per cent of all roughly 4 billion Internet users (International Telecommunication Union, 2019). These data have been used previously, for example to study labour migration patterns into the United States (State et al., 2014) and gender gaps in the US labour market (Haranko et al., 2018).

Although LinkedIn is a platform for skilled professionals, which makes it well-suited to study professional gender gaps, it is also an online population whose characteristics may differ from the actual labour force. For example, the

LinkedIn population may be younger than the actual labour force, because LinkedIn is an online platform that is likely used more by younger and/or more Internet-connected individuals. If there are systematic gender inequalities in Internet usage in a country, gender gaps on LinkedIn may reflect gender gaps in Internet use/access rather than professional gender gaps. We expect this bias to be relatively weak, however, given that we are interested in a specialized population of those employed in IT. Moreover, to address some of the bias associated with the fact that LinkedIn does not capture the actual labour force, we focus our analysis on relative female-to-male ratios rather than absolute user counts. LinkedIn data also have some advantages over labour-force survey data: LinkedIn data offer a global, comparable and harmonized perspective; have greater country coverage; have the potential to be more up-to-date than labour survey data; and can be collected frequently. Furthermore, the data can be disaggregated on the basis of many demographic and professional characteristics, allowing us to explore and explain gender gaps in different subgroups of the LinkedIn population.

### Data and analysis outline

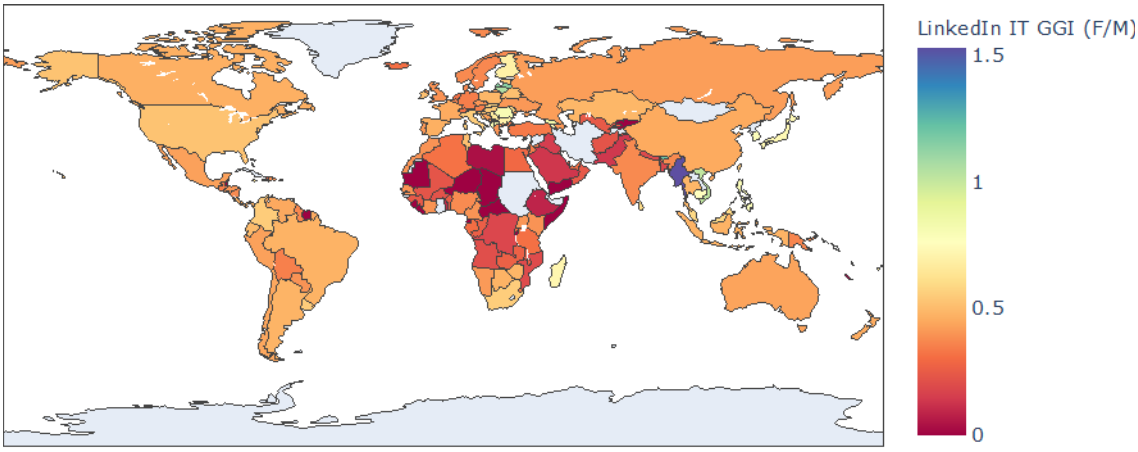
The data collected from LinkedIn's advertising platform contain about 371 million users for which country, gender and industry are available. Of these users, almost 43 million (11 per cent) report that they are employed in an IT-related industry (hardware, computer networking, semiconductors, telecommunications, wireless, computer software, Internet-related industries, IT and services, and computer and network security). LinkedIn users are classified into such industries based on the primary industry in which the company they claim to work for on their profile operates.[3] LinkedIn uses its own industry taxonomy to classify company industries (Fang, 2016), which is roughly equivalent to International Standard Industrial Classification (ISIC), albeit with some exceptions, such as the Internet industry (Zhu et al., 2018). Data on audience estimates by gender and industry are available for 181 countries. Using these aggregate counts, we analyse global variations in gender gap indices (GGIs) for different subsets of the LinkedIn population, such as those in IT industries, specific subdomains of the IT industry, and the overall (IT and non-IT) LinkedIn population. A GGI value of one would indicate parity between men and women; a value less than one indicates that women are underrepresented relative to men; and a value greater than one indicates that women are overrepresented relative to men.

We further compare LinkedIn IT GGIs with those on other platforms such as Facebook. Previous research has shown that gender gaps in Facebook use are a good proxy of country-level Internet use gender gaps (Fatehkia et al., 2018). We also examine to what extent LinkedIn IT GGIs can be explained by development indicators such as gross domestic product (GDP) per capita (World Bank Group, 2020), as well as gender-specific development indicators such as composite indicators of gender gaps in educational attainment and economic opportunity (World Economic Forum, 2019), and other gender gap indicators in education and employment, which we compute ourselves. These include gender gaps in education in both the science, technology, engineering and mathematics (STEM) and ICT domains (United Nations Educational, Scientific and Cultural Organization (UNESCO), 2019), in technical and professional employment (International Labour Organization (ILO), 2019b),[4] and in labour force participation rates (ILO, 2019c). We finally compare the LinkedIn IT GGI to the ILO IT GGI, which is a gender gap indicator from ILO computed from the female-to-male ratio in employment in ISIC divisions 58 to 63 of section J, 'Information and communication' (ILO, 2019a; United Nations Department of Economic and Social Affairs, 2008).

## Gender gaps in IT industries

What do LinkedIn gender gaps in IT look like across the globe? Figure 8.1 shows the geographic distribution of the LinkedIn GGI in IT industries. For the countries coloured light blue/grey, LinkedIn audience estimates are not available. Additionally, LinkedIn has been blocked in some countries (e.g. China, the Russian Federation and the Islamic Republic of Iran). Therefore, estimates for these countries may be biased (as discussed later). From this map, we firstly observe that in the large majority of countries worldwide, there are more men than women in IT, as indicated by GGIs smaller than one. While there are generally twice as many men as women (GGI = 0.5) in most of the Americas, Europe, Asia and Oceania, there is even more gender inequality in IT industries in

Figure 8.1. World map of the GGI (female/male) of LinkedIn users in IT industries



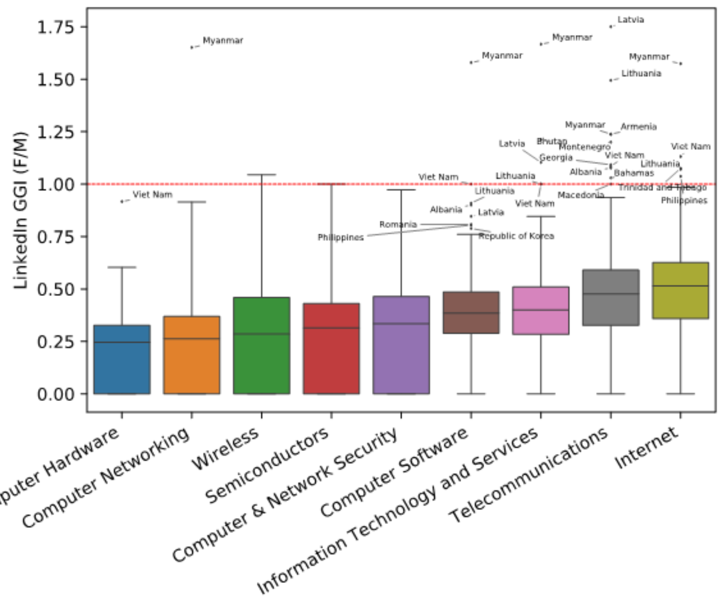

Source: Authors own 2020, unpublished, using data from LinkedIn Campaign Manager[5]

Africa with GGIs approaching zero, especially in the northern and central regions of Africa. There are a few exceptions: in Myanmar (1.53), Bhutan (1.21), Latvia (1.15), Lithuania (1.06) and Viet Nam (1.02), there are more women than men in IT industries on LinkedIn.

Are there any differences in gender inequality across various IT industries? Figure 8.2 shows a box and whisker plot for each of the IT industries in the LinkedIn data. The box ranges between the first and third quartile; the horizontal line in each box represents the median; the whiskers represent the minimum and maximum; and the sole dots represent outliers. The red horizontal line at GGI equals one shows the 'equality cut-off', and we observe that all IT industries have gender ratios far below this cut-off. While there are about four times more men than women (median GGI = 0.25) in computer hardware and computer networking, there are about twice as many men as women (median GGI = 0.5) in Internet and telecommunications.

It seems that generally there is more gender inequality in the industry defined by the United Nations Department of Economic and Social Affairs (2008) as 'computer programming, consultancy

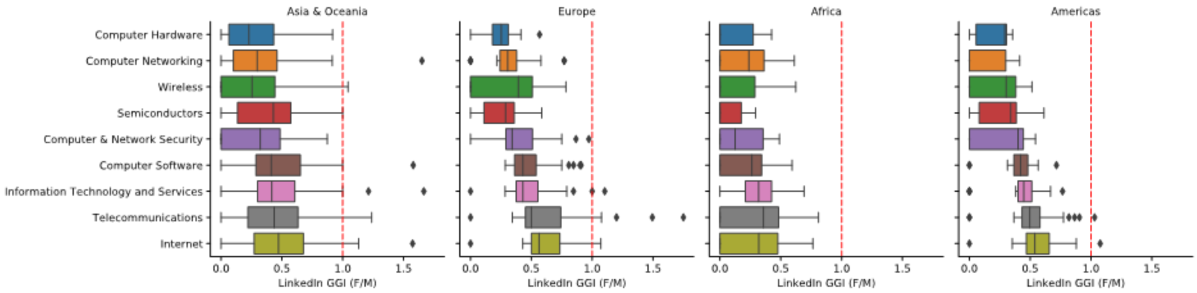
Figure 8.2. Box and whisker plot of the GGI (female/male) of LinkedIn users in IT industries across countries




Source: Authors own 2020, unpublished, using data from LinkedIn Campaign Manager[5] and related activities', than in industries classified as 'telecommunications' and 'information service activities'.[5] This may well be because, for the two sectors, the former is more related to computational work and programming, a sub-area where women's underrepresentation has been noted (Lipowiecka & Kiriti-Nganga, 2016), while the latter is focused more on communications and services, an area within ICT where women tend to be better represented (Lipowiecka & Kiriti-Nganga, 2016). Again, there are some exceptional countries for which gender equality is (almost) achieved in IT, as shown per industry in Figure 8.2. Some countries recur across these industries, such as Albania, Latvia, Lithuania, Myanmar and Viet Nam. Additionally, the telecommunications and computer software industries tend to be more gender egalitarian in, respectively, Armenia, Montenegro, Georgia, the Philippines, Romania and the Republic of Korea.

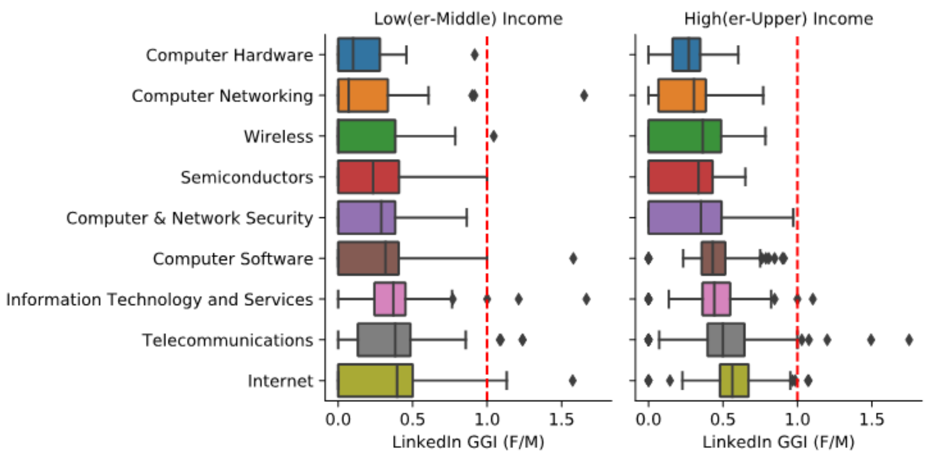
Figures 8.3 and 8.4 show the same box and whisker plot as in Figure 8.2, now faceted by geographic and income regions, respectively. The geographic regions are based on the M49 standard of the United Nations[7] and have been merged into more aggregate regions with similar sample sizes. These figures show that the highest gender inequality in IT on LinkedIn occurs in Africa, while Europe and the Americas have the smallest variation in IT gender gaps across the countries in their regions. Additionally, there are some countries in Asia, Oceania, Europe and the Americas where there are more women than men in IT, while all countries in Africa have more men than women in IT. Furthermore, high and upper-middle income countries have more gender egalitarian IT sectors than low and low-middle income countries. The patterns in gender gaps among the IT industries are similar across geographic and income regions – for example, median gender gaps are larger in IT

## Figure 8.3. Box and whisker plot of the GGI (female/male) of LinkedIn users in IT industries across countries, faceted by geographic region




Source: Authors own 2020, unpublished, using data from LinkedIn Campaign Manager[6] and United Nations Department of Economic and Social Affairs Statistics Division[6]

## Figure 8.4. Box and whisker plot of the GGI (female/male) of LinkedIn users in IT industries across countries, faceted by income region




Source: Authors own 2020, unpublished, using data from LinkedIn Campaign Manager[6] and World Bank Group[6] industries such as computer and network security and computer hardware, and they are smaller in the Internet and IT and services industries.

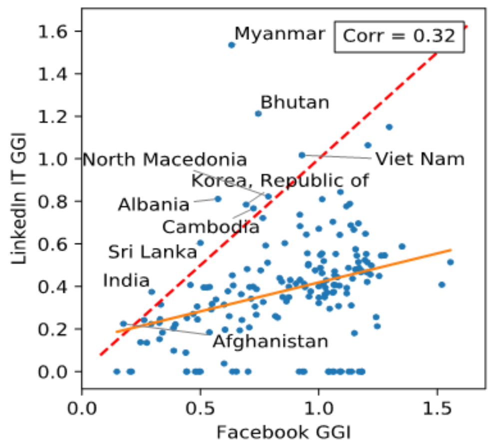
## Women in IT industries: Exploring selection effects

We now turn to compare LinkedIn gender gaps with other gender gap indicators. Figure 8.5 firstly shows a comparison between the LinkedIn IT GGI and the Facebook GGI of users aged 18+ (FB GGI), an indicator of the female-to-male ratio of monthly active Facebook users, which Fatehkia et al. (2018) have shown to be strongly predictive of ITU Internet access gender gaps. Another advantage of the FB GGI is that it provides better geographic coverage than ITU data.[8] Second, we compare the LinkedIn IT GGI with the overall LinkedIn GGI aggregated across all industries on the platform (Figure 8.6). These comparisons help to address two distinct questions. First, how do high-level digital gender gaps such as working in an IT industry, as approximated by the LinkedIn IT GGI, compare with Internet access or low-level digital gender gaps, as approximated by the FB GGI? Second, how do gender gaps in IT on LinkedIn compare with other industries more generally, as captured by the overall LinkedIn GGI?

From Figures 8.5 and 8.6, we observe that the magnitude of gender inequality in LinkedIn IT industries is larger than both gender inequality on Facebook and gender inequality on LinkedIn aggregated across all industries for most of the countries (points lie below the red dashed x=y line). However, for a handful of countries in South Asia (e.g. India, Myanmar), gender equality in IT is greater than in all industries combined on LinkedIn. In the comparison with Facebook gender gaps, these aforementioned countries – as well as Albania, Bhutan, Cambodia, North Macedonia, Sri Lanka and Viet Nam – emerge as those where there is greater gender equality in LinkedIn IT industries than in the Facebook population. In these countries, we observe a positive selection effect in the IT sector, with more women represented than would be predicted by the Internet or digital access gender gaps (proxied from Facebook usage gaps) and professional gender gaps (proxied from LinkedIn gaps).

Table 8.1 presents a linear regression model that examines the association between the Facebook GGI and LinkedIn IT GGI, as well as the association between the LinkedIn overall GGI and LinkedIn IT GGI. As expected, the Facebook GGI has a positive and statistically significant association with LinkedIn gender gaps in IT ($R^2$=0.102). Additionally, professional gender gaps on LinkedIn significantly predict the LinkedIn IT GGI, and explain a larger share of the variance therein than does the Facebook GGI ($R^2$=0.486). In both models, however, adding in the Global Gender Gap (GGG) score – a female-to-male gender gap indicator that "benchmarks national gender gaps on economic, education, health and political criteria" (World Economic Forum, 2019, p. 8) and is comparable across the globe – further improves the model fit, although the coefficient on the GGG score is not statistically significant. Interestingly, however, the coefficient on the GGG score is negative, which suggests that once we control for general patterns of gender inequality in terms of digital access or professional gender inequality, less gender egalitarian countries show a tendency towards a greater share of women in IT. This could be interpreted in light of the 'gender equality paradox' described by Stoet & Geary (2018), through which quality of life pressures in less gender egalitarian countries might work to promote girls' and women's engagement in STEM fields that offer higher job security. Nevertheless, as this pattern is only observed in a handful of countries, it is difficult to estimate this effect with more statistical precision based on the data available.

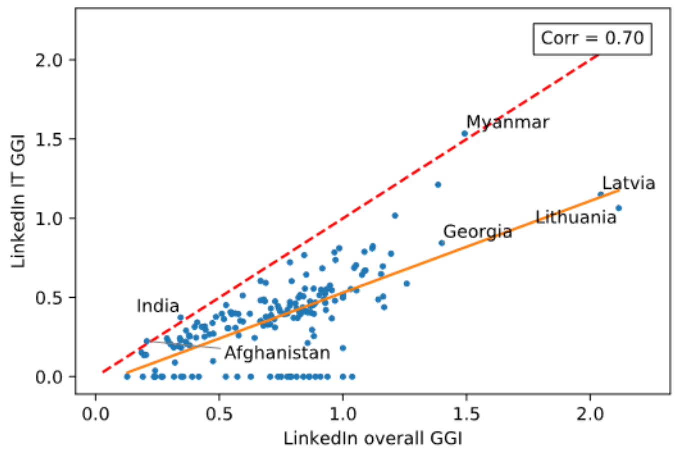
Figure 8.5. Scatter plot comparing low-level digital gender gaps as approximated by the FB GGI (horizontal axis) and high-skilled digital gender gaps as approximated by LinkedIn IT GGI (vertical axis)




Source: Authors own 2020, unpublished, using data from Facebook Marketing API[9]and LinkedIn Campaign Manager[9]

Note: Red dashed line shows y=x line, orange filled line shows fitted linear regression line.

Figure 8.6. Scatter plot comparing the overall LinkedIn GGI (horizontal axis) and the LinkedIn IT GGI (vertical axis)




Note: Red dashed line shows y=x line, orange filled line shows fitted linear regression line.

Source: Authors own 2020, unpublished, using data from LinkedIn Campaign Manager[9]

Table 8.1. Summary of linear regression models predicting the LinkedIn IT GGI from gender inequality indicators

| | Dependent variable: LinkedIn IT GGI | | | |
|---|---|---|---|---|
| | Facebook GGI | | LinkedIn overall GGI | |
| | Model 1 | Model 2 | Model 1 | Model 2 |
| Intercept | 0.147* (0.056) | 0.197 (0.241) | -0.048 (0.035) | 0.248 (0.151) |
| FB GGI | 0.273*** (0.062) | 0.382*** (0.076) | | |
| LinkedIn overall GGI | | | 0.579*** (0.044) | 0.606*** (0.042) |
| GGG score | | -0.138 (0.396) | | -0.394 (0.233) |
| N | 174 | 134 | 181 | 134 |
| $R^2$ | 0.102 | 0.229 | 0.486 | 0.646 |

*p<0.05; **p<0.01; ***p<0.001

*p<0.05; **p<0.01; ***p<0.001

Source: Authors own 2020, unpublished, using data from Facebook Marketing API[9], LinkedIn Campaign Manager[9]and World Economic Forum (2019)

## Explaining gender gaps in IT industries

In this section, we explore which (gender-specific) development variables (e.g. GDP per capita, gender gaps in economic opportunity, as described in the data and analysis outline) can help explain variation in LinkedIn IT GGIs. Table 8.2 shows the correlation coefficients of the LinkedIn IT GGI with these variables. The LinkedIn IT GGI is most strongly correlated with gender gaps in professional/technical employment, followed by composite indicators of gender gaps in economic opportunity and educational attainment as well as STEM tertiary education. Notably, the correlation of the LinkedIn IT GGI is stronger with gender-specific development variables than a variable of general economic development (GDP per capita). Additionally, gender gaps in tertiary education graduates in ICT are only weakly correlated with the LinkedIn IT GGI while gender gaps in STEM education are more strongly correlated with the LinkedIn IT GGI. Finally, gender gaps in educational attainment negatively correlate with tertiary education gender gaps in ICT and STEM, in line with the aforementioned 'gender equality paradox' (Stoet & Geary, 2018).

Table 8.2. Correlations between LinkedIn IT GGI and various development and gender-specific development indicators

| | LinkedIn IT GGI | UNESCO ICT edu. GGI | UNESCO STEM edu GGI | ILO prof./tech. GGI | ILO labour part GGI | GDP per capita | GGG econ. opp. GGI | GGG edu. att. GGI |
|---|---|---|---|---|---|---|---|---|
| **LinkedIn IT GGI** | 1.000 | 0.028 | 0.229 | 0.524 | 0.080 | 0.116 | 0.297 | 0.400 |
| **UNESCO ICT edu. GGI** | | 1.000 | 0.668 | -0.271 | -0.419 | -0.170 | -0.305 | -0.202 |
| **UNESCO STEM edu. GGI** | | | 1.000 | -0.086 | -0.415 | -0.091 | -0.259 | -0.071 |
| **ILO prof./tech. GGI** | | | | 1.000 | 0.242 | 0.150 | 0.553 | 0.602 |
| **ILO labour part GGI** | | | | | 1.000 | 0.125 | 0.810 | 0.120 |
| **GDP per capita** | | | | | | 1.000 | 0.148 | 0.416 |
| **GGG econ. opp. GGI** | | | | | | | 1.000 | 0.174 |
| **GGG edu. att. GGI** | | | | | | | | 1.000 |

Source: Authors own 2020, unpublished, using data from International Labour Organization (2019b; 2019c), LinkedIn Campaign Manager[9], United Nations Educational, Scientific and Cultural Organization (2019), World Bank Group (2020) and World Economic Forum (2019)

Table 8.3 summarizes results from two linear regression models predicting the LinkedIn IT GGI. In the first model, we include the composite gender gaps linked to educational attainment and economic opportunity, which we observe explain variation in gender inequality in IT on LinkedIn significantly, while GDP per capita does not. This suggests that gender-specific development factors may matter more than overall economic development in explaining variation in IT gender gaps. On average, gender inequality in IT is lower in countries where women are more equal to men in terms of educational and economic opportunities. The first model indicates that 22 per cent of the variance in the LinkedIn IT GGI is explained by these three variables ($R^2 = 0.216$).

The professional and technical workers' GGI, which is a component of the economic opportunity GGI, is most strongly correlated with the LinkedIn GGI (Table 8.2). In Model 2 in Table 8.3 we replace the economic opportunity GGI from Model 1 with the professional and technical workers' GGI, and add the highly correlated field-specific STEM education GGI, and remove the weakly correlated GDP indicator. With these more specific indicators, we are able to increase the explained variation in the LinkedIn IT GGI by five percentage points from 21.6 to 26.8 per cent, but at the cost of more limited country coverage of 87 instead of 134.

Table 8.3. Summary of linear regression models predicting the LinkedIn IT GGI from development indicators

| | Dependent variable: LinkedIn IT GGI | |
|---|---|---|
| | **Model 1** | **Model 2** |
| Intercept | $-1.041^{***}$ (0.262) | -0.279 (0.620) |
| Economic opportunity GGI | $0.489^{**}$ (0.161) | |
| Educational attainment GGI | $1.215^{***}$ (0.272) | 0.401 (0.669) |
| GDP per capita (scaled by one million) | -0.683 (0.855) | |
| STEM education GGI | | 0.080 (0.103) |
| Professional and technical workers GGI | | $0.289^{***}$ (0.064) |
| N | 134 | 87 |
| $R^2$ | 0.216 | 0.268 |

$^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

$^{*}p<0.05$; $^{**}p<0.01$; $^{***}p<0.001$

Source: Authors own 2020, unpublished, using data from International Labour Organization (2019b), LinkedIn Campaign Manager[9], United Nations Educational, Scientific and Cultural Organization (2019), World Bank Group (2020) and World Economic Forum (2019)

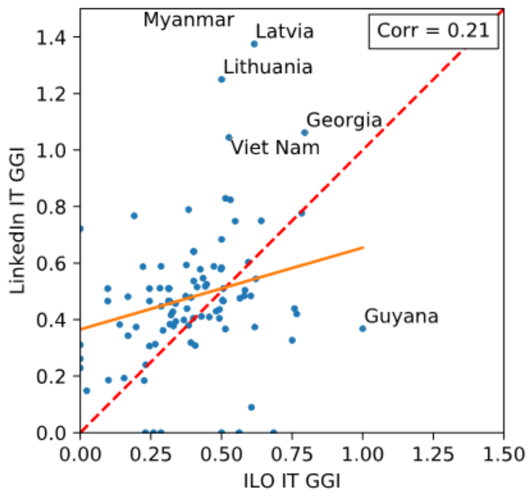
## Validating LinkedIn gender gaps in IT

Figure 8.7 shows how the LinkedIn IT GGI compares to the ILO IT GGI. To make sure that the LinkedIn IT GGI matches the ILO IT GGI – which is based on ISIC divisions 58 to 63 in section J, 'Information and communication' – as well as possible, we now additionally include the following industries when computing the LinkedIn IT GGI: motion pictures and film, broadcast media, newspapers, media production, publishing, writing and editing, computer games and online media. We observe that for most countries, gender equality in IT is overestimated on LinkedIn relative to ILO. This is particularly the case for countries like Georgia, Latvia, Lithuania, Myanmar and Viet Nam, while it is the opposite for Guyana, for example. We further observe that the correlation between the two measures is in the expected direction but of modest magnitude (0.21). Selecting only those countries with high (above median) LinkedIn penetration – calculated as the number of LinkedIn users divided by the population aged 20+ in the country – does not significantly improve the correlation. This relatively weak correlation may be linked to the fact that industries and subcategories from LinkedIn are available on a more granular level than in more aggregated ILO statistics: LinkedIn includes specific industries, while the most granular ILO data is at the level of ISIC divisions. As such, the two measures may be mismatched in terms of the industries they capture. An advantage of the LinkedIn measure over that from ILO is that it has much better country coverage: while the LinkedIn measure is available for 181 countries, the ILO measure is available for only 107 countries.

## Discussion

In this paper, we have examined explanations for and variation in professional gender gaps in IT industries as captured in the population of LinkedIn users. We have firstly shown that gender gaps in IT are substantial worldwide. Although the IT sector is skewed towards men across all geographic and income regions on average, this skewness seems to be largest in regions such as Africa, and larger in low(er-middle) income countries. The IT gender gaps we find on LinkedIn are similar to those from Eurostat (2019), at least for European countries. Possible explanations that have been offered for these gender gaps are male

Figure 8.7. Scatter plot comparing the ILO IT GGI (horizontal axis) and the LinkedIn IT GGI (vertical axis)




Source: Authors own 2020, unpublished, using data from International Labour Organization (2019a), LinkedIn Campaign Manager-[9]and World Bank Group & LinkedIn Corporation (2019)

dominance regarding usage frequency/patterns and time consumption of ICT, and male-directed work organization (Tømte, 2008; Valenduc & Vendramin, 2005).

While women are underrepresented in all IT industries considered, there is nevertheless some variation. There are almost four times more men than women in IT industries like computer hardware and networking, while there are almost twice as many men as women in the Internet and telecommunication industries. These results indicate that gender gaps are larger in computer-related IT industries than in IT industries related to communication and service. This may be because the latter require fewer digital-intensive skills than the former (Ramilo et al., 2005). Future research would benefit from further distinguishing between skills and positions within ICT to better understand where the gender gaps are largest and how these can be reduced most effectively.

Gender gaps in IT generally tend to be larger than those in other industries on LinkedIn and other online populations like Facebook. Gender-specific occupational and educational factors, and the former in particular, seem to matter more than economic development alone in explaining variation in IT gender gaps. This suggests that economic development may affect men and women differently in the professional area, and that developmental efforts that do not specifically address gender may not be sufficient in themselves to reduce professional gender inequalities in the IT sector. We have also found that in countries where there is more gender equality in educational attainment and economic opportunity, there is more gender equality in IT on average. However, there are some exceptions to these results for a handful of countries (e.g. India, Myanmar). These findings suggest that in these countries either there are more women in IT or these women may be more likely to select themselves into having a LinkedIn profile. Future research would benefit from examining this paradox and its causes further.

Our validation exercise against ILO data showed that LinkedIn generally overestimates ILO on gender equality, particularly for Albania, Latvia, Lithuania, Myanmar and Viet Nam. A possible explanation for this overestimation is that the LinkedIn and ILO GGIs are mismatched because LinkedIn data report specific industries, while ILO data report industries (or economic activity according to ILO terminology) on the more aggregate ISIC division level.[5] This highlights the importance of and need for more granular data on occupational gender gaps in order to examine and validate gender gaps across different subdomains, such as industries or skills.

Our study has some limitations. First, LinkedIn does not provide representative data, particularly for countries where penetration is low (Zagheni & Weber, 2012), and as such may overestimate gender equality; for example, when the LinkedIn population is disproportionately young, or when women are disproportionately more online than men. Additionally, LinkedIn is blocked in some countries (e.g. China, the Russian Federation, Islamic Republic of Iran), and although people in these countries can still sign up using a virtual private network, this may lead to biased audience estimates. We have focused on ratios rather than absolute numbers and contextualized potential biases in our analyses and interpretations to address these potential limitations. Second, an advantage of the LinkedIn data is that IT industries are measured on a granular level. However, this complicated our validation exercise and thus our understanding of how representative our measures of gender equality in IT industries are, particularly on a global scale. Nevertheless, positive and statistically significant correlations between gender gap indicators on economic opportunity and educational attainment point to the fact that the LinkedIn indicators we compute are measuring a phenomenon of interest, namely the representation of women in different IT industries.

## Conclusion

We have addressed gender inequality in IT using aggregate data on LinkedIn users, showing that gender gaps in IT are substantial worldwide and vary across different IT industries. Although this analysis has focused on patterns in IT industries on a global scale, future research also drawing on LinkedIn's advertising platform could explore further stratification by skills, age and seniority. Additionally, we have shown that validation of the LinkedIn IT GGI from a non-representative sample is difficult because no ground truth data with the same granular level of IT industries is available globally. Because the LinkedIn data have great potential given the large country coverage and the ability to be queried frequently, further exercises to understand potential biases in the LinkedIn data would be welcome additions to the literature. Generally, IT sectors seem more gender equal in countries that are more gender egalitarian in terms of educational attainment and occupational opportunity. This also possibly amplifies the need for women in IT in less egalitarian countries to signal themselves on LinkedIn. This paradox should not be mistaken for gender equality in IT, and governments and policy-makers should aim to further reduce not only gender gaps in IT but more generally gender gaps in educational attainment and professional opportunity. Doing so would contribute to increasing the inclusion of women in the labour market and further reducing the gender wage gap.

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# Mind the gender gap: Designing digital skills capacity-building programmes in Africa within the context of the global digital gender divide

*By Babatunde Okunoye*

## Introduction

In the past decade, technological advances in computer science and related fields have rapidly altered African society. Our capacity to work, live and interact with others is being mediated by technology in ways that would have been unimaginable over a decade ago. There has been a proliferation of the Internet and digital devices to varying degrees in the many different country contexts on the continent, and this diffusion of technology has created opportunities for those who have been fast to adopt it. The capacity to adopt technology has opened doors to employment, education, knowledge and improved welfare for millions of Africans who have leveraged access to digital devices and the Internet to improve their lives. The story is, however, different for the millions left behind in this societal march towards progress mediated by access to digital technology.

For millions across Africa, the inability to skilfully harness digital technology and all it promises has meant lack of access to life-changing knowledge networks, education and employment opportunities, among others. In Africa, as in much of the developing world, an important segment of society that has suffered neglect and disadvantage in leveraging digital technology is women. African societies are typically patriarchal, and women sometimes do not have the agency to make independent decisions which can better their lives – including the decision to access capacity building through digital skill upskilling. This situation is further exacerbated by women tending to have less access to the Internet and digital devices.

As access to digital skills and the Internet continues to transform many aspects of life and work in the twenty-first century, many organizations have designed programmes to bridge the global digital gender divide – the digital skills and access gap observed in the global female population – with varying degrees of success. This paper examines the approach that Paradigm Initiative (PIN), a social enterprise based in Nigeria, has adopted to bridge the digital gender divide and build digital skills capacity through its digital skills capacity-building programme offices in Lagos, Abia and Kano States, Nigeria. This paper explores the methods that development experts at PIN have used to ensure robust female participation in digital skills capacity development programmes in contexts where women are traditionally marginalized.

## Digital skills and the future of Africa

Advances in technology have from the earliest history of mankind modified the ways societies lived, worked and organized themselves. From the discovery and mastery of fire and the development of primitive tools by the first humans to the steam engine, electricity, railways and mechanized agriculture and industrialization, humans have acquired the skills required to master new tools and thus make great strides in improving their quality of life and that of their societies.

Perhaps no other period in the history of humankind has witnessed the same level of technology-induced changes to societal ways of life than the twenty-first century. Digital technology in particular has transformed modes of living and working in ways we could not have imagined over a decade ago. Access to computers, the Internet, and mobile digital devices and their accompanying device ecosystems is revolutionizing commerce, entertainment, learning and education, employment opportunities, healthcare delivery and even governance. For millions of people around the world, it is true to say that their life experiences are mediated through digital devices.

Citizens of different countries have been able to adapt to digital access and connectivity at different paces. Similarly, development organizations have also devised techniques to measure how well people in different country contexts are equipped to use digital access and connectivity to improve their lives. One such measurement index is the International Telecommunication Union (ITU) Information and Communication Technology (ICT) Development Index, which is used to monitor and compare developments in ICT between countries in the broad areas of ICT access, use and skills (ITU, 2017). The 2017 ICT Development Index country ranking revealed that African countries were not highly ranked in the 176 countries listed, with Mauritius the highest-ranked African country at number 72, followed by Seychelles (90), South Africa (92) and Cape Verde (93). Most of the lowest-ranked countries are in Africa. Another measurement index is the Networked Readiness Index (Kirkman, 2002), which is a key indicator of how countries are doing in the digital world; a measure which also includes how well citizens leverage digital technology to improve their lives. The Networked Readiness Index measures how well countries are leveraging ICTs to boost competitiveness and well-being.[1] In 2016 the Networked Readiness Index covered 139 economies accounting for 98.1 per cent of world gross domestic product and 53 individual indicators from organizations such as ITU, the United Nations Educational, Scientific and Cultural Organization and the World Bank.

Out of the 139 countries ranked in the 2016 Networked Readiness Index, African countries ranked near the bottom, with the highest-ranked African country being South Africa at number 65, with it and Morocco (78), Rwanda (80), Tunisia (81), Cape Verde (85), Kenya (86), Egypt (96) and Namibia (99) the only African countries ranked in the top 100. The first 10 countries in the ranking were Singapore, Finland, Sweden, Norway, the United States, the Netherlands, Switzerland, the United Kingdom, Luxembourg and Japan, in that order.

What composite indicators such as the ITU ICT Development Index and the Networked Readiness Index have shown is that Africa lags behind developed regions of the world in access to digital connectivity and skills, and has not been able to harness digital skills and access for societal development on the same scale and with the same impact as witnessed in developed regions of the world.

The problem is more pronounced in regard to the digital gender divide. In the typical patriarchal African societal context, the lack of access to digital devices and Internet connectivity which hinders societal digital development is felt more intensely among women and girls. The rest of this paper examines the digital gender divide in Africa and explores how PIN, a social enterprise founded in Nigeria in 2008, has worked to overcome this barrier to the human development of women and girls.

## The digital gender divide

The existence of a global digital gender divide has been established by researchers. All over the world, particularly in the developing world, some of the research described below reveals that women and girls have had cultural and systemic barriers raised against them, limiting their access to ICTs.

Data from the ITU report *Measuring digital development: facts and figures 2019* (2019) show that women are generally disadvantaged in their access to the Internet when compared with men. Only 48 per cent of women have access to the Internet compared with 58 per cent of men, due to cultural, financial and skills-related barriers. Also, a seminal study by the World Wide Web Foundation (2015) found that despite the proliferation of mobile phones and progress with Internet access around the world, including the developing world, these two factors have not been enough to get women online or to achieve empowerment of women through technology. Based on a survey of thousands of poor urban men and women in Cameroon, Colombia, Egypt, India, Indonesia, Kenya, Mozambique, Nigeria, Philippines and Uganda, it was discovered that while nearly all women and men own a phone, women are still nearly 50 per cent less likely to access the Internet than men in the same communities, with Internet use reported by just 37 per cent of women surveyed. In addition, once online, women are 30–50 per cent less likely than men to use the Internet to increase their income or participate in public life.

Similarly, a survey by the GSM Association of 23 low- and middle-income countries (LMICs) found that despite an increasingly connected world powered by access to mobile devices, women are being left behind (GSM Association, 2018). The research found that although mobile connectivity is spreading quickly, it is not spreading equally. It also found that in LMICs, women have less access to technology than men, especially mobile technology. Other key findings of the study revealed that in LMICs:

- On average, women are 10 per cent less likely to own a mobile phone than men, which translates into 184 million fewer women owning mobile phones.
- Even when women own mobile phones, there is a significant gender gap in usage, particularly for more transformational services such as mobile Internet.
- Over 1.2 billion women in LMICs do not use mobile Internet. Women are, on average, 26 per cent less likely to use mobile Internet than men. Even among mobile owners, women are 18 per cent less likely than men to use mobile Internet.

These research findings (GSMA, 2018) highlight some of the ways women are disadvantaged in accessing opportunities brought about by digital connectivity, and mirror the disadvantages women and girls face in accessing digital skills and the opportunities they bring. A common denominator in research which reveals the digital gender divide (such as the three studies cited above) is the context of this divide, which is usually LMICs in the Global South. In developed countries, women tend to have more access to ICTs, including the Internet, compared with the Global South.

Nevertheless, evidence suggests that translating this access to ICTs into digital skills and impacts in technology careers and industries focused around information technology – such as computer programming, data science and artificial intelligence – is still a major hurdle for women, even in developed countries. For example, in the United States in 2017, women owned only 5 per cent of technology start-ups, earned only 28 per cent of computer science degrees, filled only 25 per cent of computing jobs and held only 11 per cent of executive positions in Silicon Valley, despite about 74 per cent of young girls expressing interest in science, technology, engineering and mathematics fields and computer science (Lazzaro, 2017). In Europe, with the exception of the Netherlands, women's share of technology-intensive employment in the years 2008–2010 was just over 25 per cent. This is despite the fact that women remain well-represented in universities, with women making up 49 per cent of tertiary students in the science, mathematics, computer, engineering and manufacturing fields in 17 European countries in 2012 (MacBride, 2015). In the McKinsey report *Women matter: Africa* (Moodley et al., 2016), it was reported that women held only 29 per cent and 33 per cent respectively of middle and senior management roles in the telecoms, media and technology industries in Africa.

What the data above suggest is that although women in the developing world are disadvantaged in their access to digital devices and skills when compared with women in developed countries, the outcomes in terms of access to opportunities in the technology sector are the same in both regions. This suggests that although women do not lack interest in technology, other factors along their path to progress in technology careers are to blame for their poor representation in these careers. For many women, these factors include the absence of suitable role models, lack of representation in staff trainers in digital skills capacity development institutions, and the influence of authority figures. In Africa, these factors work in tandem with an already disadvantaged position of limited access to digital devices and skills to hold back the potential of millions of women.

The next section of this paper examines how PIN, a social enterprise in Africa working on digital inclusion and digital rights, has devised programmes which overcome these factors to set women along the path to successfully using technology to improve the quality of their lives.

## Paradigm Initiative: A unique approach defying cultural stereotypes

PIN is a non-profit social enterprise that builds ICT-enabled support systems and advocates for digital rights in order to improve the livelihoods of underserved young Africans. PIN has worked with government, civil society, private institutions and international organizations, including United Nations institutions, to set standards in ICT education, telecentre support, ICT applications in rural areas and other ICT interventions in Nigeria.

Since 2007, PIN has worked in underserved communities across Nigeria – in Ajegunle, Lagos State; Ngwa Road, Aba, Abia State; and Dakata,

Table 9.1. PIN's digital skills capacity-building programme in Ajegunle enrolment data, 2007–2019.

| Year | Number of young men | Number of young women | Total |
|---|---|---|---|
| 2007–2011 | 83 | 62 | 145 |
| 2012 | 34 | 24 | 58 |
| 2013 | 34 | 37 | 71 |
| 2014 | 76 | 52 | 128 |
| 2015 | 69 | 85 | 154 |
| 2016 | 34 | 41 | 75 |
| 2017 | 24 | 33 | 57 |
| 2018 | 35 | 35 | 70 |
| 2019 | 35 | 35 | 70 |

Source: Paradigm Initiative

Kano State – empowering young people with crucial digital skills, life skills (such as etiquette and emotional intelligence) and business skills. PIN is dedicated to bridging the digital gap by taking digital inclusion opportunities to young people where they are. Part of PIN's Digital Inclusion programme is the innovative digital skills capacity-building programme called Life Skills, ICTs, Financial Literacy and Entrepreneurship (LIFE) training and the Dufuna programme, a six-month hands-on, project-centric software engineering training programme for recent graduates of tertiary institutions. Dufuna equips students with skills in HTML, CSS, Javascript, PHP, SQL, algorithms and data structures, and software version control.

In the communities where PIN works, youths have typically not received sufficient support from government social support systems. The LIFE digital skills capacity-building programme targets these youths and takes them through this 12-week training programme which readies them for employment opportunities where digital skills are a premium. Youths selected for the LIFE programme are chosen after public announcements of new class sessions in local communities and on social media. An interview process with staff then follows to ensure that those who apply cannot normally afford to get training similar to that given in the LIFE programme elsewhere, and that they demonstrate an understanding of how they intend to use the skills learned after completing the programme.

At the inception of PIN's LIFE programme in 2007, boys always outnumbered girls in enrolment and completion of classes. Recognizing this problem, the organization set out to institute policies to tackle this manifestation of the digital gender divide by directly confronting the factors which hindered the enrolment of girls in digital skills empowerment programmes in Nigeria. Implementing these policies resulted in classes with a near-equal number of girls and boys, and in some instances with girls outnumbering boys (see Table 9.1). Some of the factors PIN confronted included suitable role models, lack of representation of women in training institutions, the influence of authority figures and the lack of specific gender targeting in training recruitment.

## Lack of representation

One of the most important policies which contributed to the increased participation of women and girls in PIN's digital skills capacity-building programmes is the mandatory representation of women in the programme design. PIN's approach took the form of the deliberate recruitment of women and girls from the local community as key personnel in the organization's digital skills capacity-building programmes.

This deliberate programme design was effective across the training centres. In Ajegunle and Kano, women are represented in the programme staff as programme assistants and office assistants, and have played key roles in community mobilization to enrol more women and girls in the programme. They have done this through community mobilization: talking with families about the importance of permitting their girls to attend the training, and by encouraging those who enrol to persevere to complete the programme.

## Interaction with authority figures

One of the most important factors which was observed to influence successful enrolment and

Figure 9.1. PIN's programme assistant in the Ajegunle, Lagos Digital Skills Training Centre taking a class

Source: Paradigm Initiative

completion of PIN's digital capacity-building training programmes was the buy-in of individuals who serve as authority figures in the lives of young people. PIN programmes target young people aged 16–28, and some young people within this age range are still under the authority of their parents, who can grant or deny permission to participate in these programmes. For those who are not under parental supervision, their ability to engage with PIN programmes is subject to the buy-in of local community leaders.

Within the context of Nigeria, this is more the case for young women, whose place is perceived to be at home helping with household chores. Since PIN began offering its digital skills capacity-building programmes in 2007, there have been numerous cases where siblings of the same parents were selected to participate, with the young men granted permission to participate by parents or guardians while permission was denied to the young women, who parents wanted to retain at home to help with household chores.

In the context of the underserved communities where PIN works, this situation is even more pronounced given the socio-economic context, in which young women tend to be tasked with co-working with their parents in order to provide for the home. PIN's digital skills capacity intervention within this context involves weekly consultation meetings with parents and community leaders in their homes and offices. During these face-to-face meetings, PIN staff explain details of PIN's work and approach to these important stakeholders, clarifying that the digital skills imparted will improve the economic prospects of their female children. These meetings have significantly improved women's participation in and completion of the programmes.

## The role of career role models

Although women have become better represented in technology-related careers, not many young women who aspire to these roles are aware of this increasing representation of women. Hence the perception persists among many young people that technology careers are not meant for women but are better suited to men. Well aware of this problem, PIN's LIFE programme has embedded mentoring sessions where young women aged 16–28 can interact with women who have succeeded in careers leveraging the power of technology. Through this process of sustained interaction, the psychological limitations which have typically held women back are overcome, and women are inspired through the examples of other women to aspire to careers enabled by digital technology.

## Conclusion: Neglecting a significant part of the population

In 2015, PIN partnered with the World Wide Web Foundation to conduct pilot research (World Wide Web Foundation, 2015) on women's access to ICTs. The research found that despite the proliferation of mobile phones and progress with Internet access across the world, including the developing world, these two factors have not been enough to

Figure 9.2. Programme Assistant in PIN's digital skills capacity-building programme in Ajegunle, Lagos in a meeting with parents and community leaders

Source: Paradigm Initiative

get women online, or to achieve empowerment of women through technology. Across 10 countries in the Global South, the research found that women were disadvantaged relative to men in both access to and meaningful use of digital devices and connectivity. These findings mirror the broader state of women who are disadvantaged in their quest to build digital skills capacity.

Nevertheless, in the past decade a number of organizations around the world – particularly in developing country contexts – have developed innovative digital skills capacity-building programmes to bridge this digital gender divide. These programmes, an example of which is PIN's LIFE programme, deploy approaches that challenge the societal contexts which hinder women's access to digital skills capacity building. An important innovation in PIN's contribution to bridging the global gender divide is its 'training relay' method, where students it has trained are mandated to train others as part of their reporting

Figure 9.3. A mentoring session with students at PIN's digital skills capacity-building programme in Ajegunle, Lagos

Source: Paradigm Initiative

and certification requirements. Through this relay method, the skills and knowledge they have gained are thus taught to a network of other recipients and benefit the wider community.

In the past few decades, significant development support has poured into efforts which emphasize the empowerment of women and girls in the Global South. This support stemmed from the realization of the important dividends of the empowerment of women for family, societal and national development (Francis, 1991), and in response to the global digital gender divide as described in this paper. In many countries of the Global South, not only do women make up at least half of the population,[2] but it has been established that women who are empowered contribute to the development of their children and families. In recognition of the immense role women play in homes and communities, PIN's LIFE programme works to strategically empower women through its offices in underserved communities in Nigeria.

In today's digitally connected world where ICTs represent possibly the next frontier of development for many nations, or at least represent an important enabler of development, no effort must be spared to connect as many women as possible to the dividends of digital skills and connectivity.

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## About the Contributors

### Thomas Bourgeau

Thomas Bourgeau is a senior industrial innovator working mainly on topics such as enhanced cellular networks, software-defined networks, IoT and learning management systems. He is currently acting as Chief Technical Officer of a virtual reality French start-up and as a senior consultant in digital transformation at the Swiss company KB Digital. He is an active teacher and coach in both academia and industry and has written more than 20 research papers on topics such as emerging IoT technologies, network architectures and immersive technologies. Bourgeau has a PhD in Computer Science with expertise in digital transition and new network systems (IoT, software-defined networks). He earned his MSc in Electronics in 2005 and his PhD in Computer Science in 2013, both from the University of Pierre and Marie Curie in France.

### Ingrid Brudvig

Ingrid Brudvig is an anthropologist whose work focuses on multi-country research and advocacy projects to close the gender gap in technology, data and policymaking. Ingrid is the Web Foundation's Gender Policy Manager, where she manages the Women's Rights Online initiative and network of partner organizations across Africa, Asia and Latin America. Prior to joining the Web Foundation, Ingrid coordinated a network of anthropologists across Africa studying the intersection of mobility, ICTs and marginality across the African continent. She has worked on projects and conducted fieldwork in the areas of gender mainstreaming, women's rights and technology, South-South migration, public health and education across South Africa. Ingrid holds a PhD in Social Anthropology from the University of Cape Town.

### Elinor Carmi

Elinor Carmi is a digital rights advocate, feminist, researcher and journalist who has been working, writing and teaching on Internet standards, digital literacy, sound studies and Internet governance. Elinor is a Postdoctoral Research Associate at Liverpool University, UK, working on several Economic and Social Research Council and Arts and Humanities Research Council projects, and part of the project funded by the Nuffield Foundation, 'Me and My Big Data: Developing UK Citizens' Data Literacies'. Elinor's current research projects involve the politics of content moderation and personalization, women's historical contributions to media technologies, and data literacies in the age of dis-/mis-information. Carmi's second monograph, on Peter Lang, was titled 'Media Distortions: Understanding the Power Behind Spam, Noise, and Other Deviant Media', and published in March 2020.

For the past decade Carmi has been organizing events around data politics, digital rights and digital literacy. In 2019, she organized the Digital Inclusion Policy and Research Conference, and will organize the next edition in 2021. Together with Professor Simeon Yates, she has been the academic research collaborator of the Digital Leaders network. In addition, Carmi is part of the Department for Digital, Culture, Media and Sport's digital skills and inclusion research working group. She is also the Communication Chair of the Global Internet Governance Academic Network. In February 2020 she was invited to give evidence on digital literacy to the House of Lords Select Committee on Democracy and Digital Technologies, at the British Parliament.

### Hakima Chaouchi

Hakima Chaouchi is a Professor, PhD at Institut Polytechnique de Paris/Telecom Sud Paris. With a strong research background in network, telecommunication and protocols design; research on IoT technologies and architectures, security and access control; and a background in innovation, entrepreneurship and technology transfer, she leads a research group on emerging services and communication technologies. She focuses her research on efficient, reliable and secure communications technologies applied to wireless IoT, 5G mobile communications and research on IoT data management and analytics applied to Industry 4.0 and smart cities.

She is active in different international conferences as chair or Technical Programme Committee member, and in various international editorial journals. She is currently acting as a national expert and representative in the ICT and cybersecurity Horizon 2020 programme following her position as a scientific adviser to French ministries on research and innovation in ICT and cybersecurity. She is also active in technology standardization bodies such as the ITU Telecommunication Standardization Sector and the Internet Engineering Task Force. In her former EU position as EIT Digital Doctoral Training Centre manager, she developed an innovative education program to coach and build innovation and the entrepreneurial mindset in technology PhD students. As a full professor she is active in building new innovative pedagogical programmes and coaching students. She is involved in establishing the Erasmus+ Knowledge Alliance – which is looking for new approaches to build knowledge in a time of fast-growing technologies – at the EU level.

### Kiran Garimella

Kiran Garimella is a postdoctoral researcher at the Institute for Data, Systems and Society at Massachusetts Institute of Technology (MIT). Before joining MIT, Kiran was a postdoctoral researcher at the Swiss Federal Institute of Technology Lausanne (EPFL). His research focuses on using digital data for social good, including areas such as polarization, misinformation and human migration. His work on studying and mitigating polarization on social media won best student paper awards at reputed computer science conferences. Kiran received his PhD from Aalto University, Finland; and his master's and bachelor's from the International Institute of Information Technology, Hyderabad, India. Prior to his PhD, he worked as a Research Engineer at Yahoo Research, Barcelona, and the Qatar Computing Research Institute, Doha.

### Ridhi Kashyap

Ridhi Kashyap is an Associate Professor of Social Demography and Professorial Fellow of Nuffield College at the University of Oxford. She completed her doctorate jointly affiliated with the University of Oxford and Max Planck Institute for Demographic Research in 2017. Kashyap conducts research and teaches in the areas of demography and sociology. Her substantive interests span topics such as gender inequality, health, marriage and family, and ethnicity and migration. She uses both quantitative social data sources – such as surveys, official statistics and censuses – and digital trace data sources in her research. She is interested in the use of digital and computational innovations more broadly, both in terms of methods and novel datasets, to study population dynamics, human development and social inequalities. She has led pioneering work on the use of online data sources to monitor digital gender inequalities, as illustrated on www.digitalgendergaps.org.

### Eleanor Lockley

Eleanor Lockley is currently a Research Fellow in the Communication and Computing Research Centre at Sheffield Hallam University. Her research focuses around the sociology of communication and digital media: how people make use of and interact with technology and digital media, as well as issues associated with new media and society, digital inclusion, and digital and media literacy. Eleanor has 11 years of experience working on interdisciplinary research projects at Sheffield Hallam University (including commercial consultancy through knowledge transfer activity as well as academic-based project work). From providing groups of adult refugee learners with ICT and journalism training and helping to enhance their digital and media skills, to studying digital inclusion in association with Sheffield City Council, these projects have resulted in local community interventions, including setting up computer clubs for people who were otherwise considered to be 'digitally excluded'.

Her postdoctoral research focused on the social impact of the mobile phone in public and private. The research specifically concentrated on how people manage contextualized mobile phone use during social interactions in public spaces. It also examined how people make use of their mobile phones to manage their private relationships. Themes throughout the research concerned interaction management, face management and relationship management, and made use of Goffman's (1959, 1963) concepts of behaviour in public.

### Goodiel Moshi

Goodiel C. Moshi is a lecturer and researcher at the Department of Computer Electronics and Telecommunications Engineering, University of Dodoma, Tanzania. He has also been Director of ICT at the same institution since 2016 and a Tanzania country nodal for Research ICT Africa, a leading ICT think tank in Africa. He holds a PhD and a master's degree from Waseda University, Tokyo, Japan, both of which specialized in telecommunications policy, regulation and economics. Both degrees were completed under the Japanese Government (Monbukagakusho: MEXT) scholarship programme. Prior to taking up the scholarship, Moshi completed a bachelor's degree in Information and Communications Technology from Mzumbe University, Tanzania. His research interests include new technologies and regulation and adoption of those technologies, particularly in developing countries. His work has been published in leading telecommunications journals, particularly *Telecommunications Policy*.

### Hilda Mwakatumbula

Hilda Mwakatumbula is a researcher at the Research on Poverty Alleviation (REPOA) research institute in Tanzania. She obtained her PhD from Waseda University in Tokyo, Japan, focusing on ICT economics, business and policy. Before joining REPOA, Hilda was a postdoctoral researcher at the University of Dar es Salaam Department of Economics, Centre for Behavioural Studies. Her research interests include the utilization of digital technologies for developing countries, consumer empowerment and protection, and gender. She has almost 10 years of research experience in ICT economics, consumers and policy. Hilda has taken part in some multinational research projects, including After Access: ICT Access and Use –2017 (conducted in 16 countries on three continents), and is a past recipient of the Japanese Government (Monbukagakusho: MEXT) scholarship.

### Babatunde Okunoye

Babatunde Okunoye is the Research Officer at Paradigm Initiative, a social enterprise working on digital inclusion and rights across Africa. A 2018 Fellow of the African School on Internet Governance, Babatunde has collaborated on research projects with organizations such as the Open Observatory of Network Interference, the Web Foundation and Collaboration on International ICT Policy in East and Southern Africa. Babatunde's research focuses on the application of ICTs for development, particularly in the Global South.

### Alicja Pawluczuk

Alicja Pawluczuk is a Young Information and Communication Technologies and Development Research Fellow at the United Nations University Institute in Macau and a Research Associate at the University of Liverpool project 'Me and My Big Data'. Alicja's research and community education practice focuses on digital inclusion, and digital and data literacy. She is a founder of digital inclusion and digital storytelling collective Digital Beez. Through the use of participatory, critical and multidisciplinary approaches, she aims to examine the power dynamics associated with the digital and data divides. Alicja's digital inclusion practice is rooted in the areas of democratic education and community development. She has extensive experience in digital inclusion community projects' design, facilitation and evaluation. Both her community engagement practice and her research are characterized by the use of experimental and interactive methodologies.

Over the last 10 years, her work has been responding to and changing in accordance with the digitization of society. Alicja has a track record of peer-reviewed publications and cross-disciplinary public engagement activates. She has managed and contributed to digital literacy and digital inclusion and learning projects with the United Nations, the Council of Europe and Erasmus. Alicja blogs about her research and her practice at www .alicjapawluczuk.com.

### Nanjira Sambuli

Nanjira Sambuli is a researcher, policy analyst and advocacy strategist who works to understand the intersection of ICT adoption with governance, media, entrepreneurship and culture through a gender lens. Nanjira led policy advocacy to promote digital equality in access to and use of the web at the World Wide Web Foundation (2016–2020). During her time at the Foundation, she spearheaded gender-responsive ICT policy, which included the Women's Rights Online network and the design and execution of the eSkills4Policymakers workshop series.

She previously worked at iHub in Nairobi, where she provided strategic guidance for growth of technology innovation research in the East Africa region. Nanjira is a Commissioner on the Lancet and Financial Times Global Commission (Governing Health Futures 2030), a board member at The New Humanitarian and a member of the United Kingdom Department for International Development Digital Advisory Panel. She also advises the Triple A: Affirmative Action for Algorithms initiative by Women@TheTable, and the World Economic

Forum project, 'Preparing Civil Society for the Fourth Industrial Revolution'. Sambuli served as a panel member on the United Nations Secretary-General's High-Level Panel on Digital Cooperation (2018–2019) and as a deputy on the United Nations Secretary-General's High-Level Panel for Women's Economic Empowerment (2016–2017).

### Estephanie Silva-Avellaneda

Estephanie Silva-Avellaneda is the Research Management Coordinator of the International School of Economic and Administrative Sciences at Universidad de La Sabana, Colombia. She holds a master's degree in Design and Process Management and an Agro-industrial Production Engineering degree from the Universidad de La Sabana, Colombia. She has over six years of research experience in food science and data analytics.

### Elyn L. Solano-Charris

Elyn L. Solano-Charris is Associate Professor and Faculty and Research Director of the International School of Economic and Administrative Sciences at Universidad de La Sabana, Colombia. She has a PhD in Optimization and Reliability Systems from the University of Technology of Troyes, France. She has been an author and peer reviewer for high-impact journals and academic events, and her main research interests are supply chain management, scheduling, optimization, transportation and sustainability.

### Susan Teltscher

Susan Teltscher is Head of the Capacity & Digital Skills Development Division (CSD). She is responsible for ensuring the delivery of ICT-related capacity building activities and projects, with the objective to enhance knowledge and capabilities in the field of ICT, in particular in developing countries. This includes the direction and coordination of the ITU Academy and of the ITU Centers of Excellence network, working in partnership with Government, industry and academic institutions. Before joining CSD she was Head of the ICT Data and Analytics Division where she was responsible for ITU's work on the collection, harmonization, analysis and dissemination of ICT statistics worldwide, and for the production of analytical reports on global and regional trends in ICT, including the annual ITU Measuring the Information Society Report and the ICT Development Index. Before joining ITU in July 2008, she was Chief of the ICT Policy and Analysis Unit, ICT and E-Business Branch, of the United Nations Conference on Trade and Development, Geneva. She received her Ph.D. in Economic Geography in 1992 from the University of Washington (Seattle, United States).

### Dhanaraj Thakur

Dhanaraj Thakur is the Research Director at the Web Foundation, where he leads research on broadband access and affordability, gender equality and data rights, with an emphasis on low and middle income countries. As a global expert on these issues he has been interviewed and quoted in numerous news media including the Inter Press Service news, CNBC Africa, the Guardian (UK), the Financial Times, Wired, and other regional and local news outlets. He has published over 35 peer-reviewed journal articles, book chapters and conference papers. He is also the lead author of numerous research reports for major multilateral development banks, civil society organizations and governments.

Dhanaraj previously held faculty positions at Tennessee State University (Nashville, USA) and the University of the West Indies (Mona, Jamaica). He was also a Fellow at the Institute for Gender and Development Studies (University of the West Indies). Prior to that he worked in the area of community development with the Government of Jamaica. A former Fulbright scholar, Inter-American Development Bank scholar, and Internet Society (ISOC) Ambassador, Dhanaraj brings an interdisciplinary background to his work that includes public policy, international development and computer science. He holds a PhD in Public Policy from the Georgia Institute of Technology (USA), and is a graduate of the London School of Economics, the University of the West Indies, and the University of Technology in Jamaica.

### Lav R. Varshney

Lav R. Varshney is an assistant professor of electrical and computer engineering, computer science, neuroscience, industrial engineering, and digital agriculture at the University of Illinois at Urbana-Champaign, and serves as a Disruption Fellow in the College of Business there. He is also Chief Scientist at Ensaras, Inc., a start-up that works at the intersection of AI and wastewater treatment. On leave, he is currently a principal research scientist at Salesforce Research, Palo Alto, California, focusing on AI ethics and AI for social good.

Lav received a BSc (magna cum laude) with honours from Cornell University in 2004. He received MSc, EE, and PhD degrees from the Massachusetts Institute of Technology in 2006, 2008 and 2010, where his theses received the E. A. Guillemin Thesis Award and the J.-A. Kong Award Honourable Mention. He was a research staff member at the IBM Thomas J. Watson Research Center from 2010 until 2013, where he led the design and development of the Chef Watson computational creativity system. His research interests include information theory and artificial intelligence. Lav also serves on the Advisory Board of the AI XPRIZE. He recently appeared in the documentary series 'The Age of AI', hosted by Robert Downey, Jr.

### Carolina Velásquez-Mora

Carolina Velásquez-Mora is Programme Director of the Bachelor of International Business programme at Universidad de La Sabana, Colombia. She holds an MBA from INALDE Business School, Colombia and a master's degree in Commerce in Business from Macquarie University, Australia. Carolina has been working at Universidad de La Sabana since 2014, first as Head of Internationalization at the International School of Economic and Administrative Sciences and then as Programme Director, and has professional experience in negotiation, commerce, project management and corporate relations in retail companies.

### Florianne C.J. Verkroost

Florianne Verkroost is a PhD candidate at the University of Oxford. She holds an MSc degree in Econometrics and Management Science from Erasmus University, Rotterdam and an honours BSc in Technology and Liberal Arts and Sciences from the University of Twente, Netherlands. Florianne is passionate about applying her interdisciplinary knowledge and skills to address societal problems of inequality, making extensive use of advanced computational methods and innovative digital data. Methodologically, she is interested in (Bayesian) statistics, machine and deep learning, agent-based simulations and big data. Her substantive topics of interest include socioeconomic inequalities by gender and parental status as well as tracking digital gender gaps. Florianne won the award of best researcher in economics and society at the Dutch Student Research Conference for her work on the gender wage gap.

### Ingmar Weber

Ingmar Weber is the Research Director for Social Computing at the Qatar Computing Research Institute. His interdisciplinary research uses large amounts of online data from social media and other sources to study human behaviour. Particular topics of interest include quantifying international migration using digital methods, tracking digital gender gaps, looking at political polarization and extremism, and precision public health. As an undergraduate, he studied mathematics at the University of Cambridge (1999–2003), before pursuing a PhD at the Max Planck Institute for Computer Science (2003–2007). Ingmar currently serves as an Association for Computing Machinery Distinguished Speaker.

### Bridgette Wessels

Bridgette Wessels' research focuses on social change, media including digital media, and cultural participation. She has extensive research experience in the area of digital culture in a wide range of areas, such as the public sphere, the creative and cultural industries, media and new media, e-services, and digital culture in everyday life studies. She is particularly interested in audiences and cultural engagement in regional contexts and she is just finishing a project that focuses on regional media in a global media age in Sweden (RegPress) as well as research with the Courtauld Gallery on audience engagement, and a study of regional film audiences in the north of England.

Bridgette has recently finished working on projects that focus on the open data and knowledge society, participatory design for digital research in early modern newsbooks, mainstreaming telehealth, and the role of social media in the new dynamics of cultural audiences. She has also just finished working on the relationship between social media and political culture. These foci also involve addressing methodological challenges in terms of working with big data in meaningful ways. Bridgette has undertaken comparative research in Europe that addresses diversity, participation and communication. She has also undertaken global research in developing countries looking at inclusion and the digital divide.

Bridgette has written six books, including *Open Data and the Knowledge Society* (Amsterdam University Press), *Social Change: Process and Context* (Palgrave, 2014), and *Understanding the Internet: A socio-cultural perspective* (Palgrave). She has published numerous articles and has received research funding from research councils in the UK as well as European funding. She has been on advisory boards for the EU, UK Government, the Association of Southeast Asian nations, the Consumer Action Network, Australia, and the EU e-Forum Privacy Group, including the EU ICT–China programme.

### Simeon J. Yates

Simeon Yates is Associate Head of School (Research and Impact) and Director of the Centre for Digital Humanities and Social Science at the University of Liverpool. His research on the social, political and cultural impacts of digital media includes a long-standing focus on digital media and interpersonal interaction. More recently, he has worked on projects that address issues of digital inclusion and exclusion and projects that address the use of digital technologies in the context of security and crises, with this work funded by the Economic and Social Research Council, the Arts and Humanities Research Council, EU and industry. Simeon's work has often been interdisciplinary and has predominantly involved creative and digital industry partners. While at Sheffield Hallam, he was one of the leads on a major interdisciplinary programme (Engineering for Life) funded by the Engineering and Physical Sciences Research Council.

Simeon has been researching the impacts of the Internet and new/digital media on language and culture since 1990. His PhD thesis (1993) is a large-scale linguistic comparison of speech, writing and online interaction. Subsequent published work has covered analyses of gender differences in computer-mediated communication, gender and computer gaming, e-mail and letter writing, science in the mass media, and textbooks on social research methods – in particular, linguistic and discourse analytic methods. He was previously the Director of the Institute of Cultural Capital, a strategic collaboration between the University of Liverpool and Liverpool John Moores University. He established the Cultural, Communication and Computing Research Institute at Sheffield Hallam University, and has previously worked at the Open University and the University of Leeds. As well as a background in social science, Simeon has an interest and training in science (geology).

### Emilio Zagheni

Emilio Zagheni is Director of the Max Planck Institute for Demographic Research and Head of the Lab of Digital and Computational Demography. Formerly, he was Associate Professor of Sociology at the University of Washington and Training Director at the Center for Studies in Demography and Ecology. Zagheni is best known for his work on using Internet and social media data to study migration processes. In 2016 he received the Trailblazer Award for Demographic Analysis from the European Association for Population Studies for his role in developing the field of digital and computational demography. As co-Chair of the Digital Demography Panel of the International Union for the Scientific Study of Population, he has contributed to the training of PhD students, postdoctoral researchers and early-career faculty through workshops offered at major venues for demographers and computational social scientists.

# List of Acronyms

| | |
|---|---|
| AI | Artificial Intelligence |
| EU | European Union |
| FB GGI | Facebook Gender Gap Index |
| GDP | Gross Domestic Product |
| GGG | Global Gender Gap |
| GGI | Gender Gap Index |
| HEI | Higher Education Institution |
| ICT | Information and Communication Technology |
| ILO | International Labour Organization |
| IoT | Internet of Things |
| ISIC | International Standard Industrial Classification |
| IT | Information Technology |
| ITU | International Telecommunication Union |
| JOLTS | Job Openings and Labor Turnover Survey |
| LIFE | Life Skills, ICTs, Financial Literacy and Entrepreneurship |
| LMICs | Low- and Middle-Income Countries |
| O*NET | Occupation Information Network |
| PIN | Paradigm Initiative |
| SDG | Sustainable Development Goal |
| SMAC | Social, Mobility, Analytics and Cloud |
| SSA | Sub-Saharan Africa |
| STEM | Science, Technology, Engineering and Mathematics |
| UK | United Kingdom |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |

International Telecommunication Union
Telecommunication Development Bureau
Place des Nations
CH-1211 Geneva 20
Switzerland

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