DISCUSSION PAPER

THE DIGITAL REVOLUTION: Implications for Gender Equality and Women's Rights 25 Years after Beijing

No. 36, August 2020

JUDY WAJCMAN, ERIN YOUNG AND ANNA FITZMAURICE

UN WOMEN

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SUMMARY

The digital revolution brings immense potential to improve social and economic outcomes for women. Yet, it also poses the risk of perpetuating existing patterns of gender inequality. Despite a number of important initiatives, a significant digital gender gap remains, limiting the equitable realization of the benefits of digital transformation across high, low and middle-income countries. This report begins by outlining a conceptual framework for understanding the mutual shaping relationship between gender and technology. It then focuses on three areas in order to identify opportunities and risks in the digital revolution: education, work, and social/welfare services.

First, we examine the ways in which the digital skills gap in the education sector can lead to the encoding of gender biases in technology, how education technologies might help or hinder the situation, and the masculine stereotypes within STEM fields. Second, we consider the implications for women of the changing world of work, such as the increasing precarity of jobs and 'masculine defaults' within tech workplace climates. We show how the underrepresentation of women in technical fields partakes in a feedback loop, amplifying gender bias in AI and machine learning systems. Third, we look at the benefits and risks of the implementation of automated decision-making in social and welfare services. The human rights of the most vulnerable are especially at risk in the digital welfare state and we present pathways for ensuring gender equality, such as establishing external accountability mechanisms. The report concludes by offering concrete policy recommendations to advance progress for women's rights within the digital society.

RÉSUMÉ

La révolution numérique peut considérablement améliorer la situation sociale et économique des femmes. Elle risque néanmoins également de perpétrer les schémas actuels d'inégalités entre les sexes. Malgré un certain nombre d'initiatives importantes, un écart numérique important subsiste entre les sexes, ce qui entrave l'apport équitable de bénéfices liés à la transformation numérique dans les pays à revenus moyens, élevés et faibles. Ce rapport commence par définir un cadre conceptuel permettant de comprendre la relation interdépendante entre le genre et la technologie. Il se concentre ensuite sur trois domaines afin d'identifier les possibilités et les risques posés par la révolution numérique : éducation, travail, et services sociaux/d'aide sociale.

Premièrement, nous examinons les différentes manières par lesquelles l'écart des compétences numériques dans le secteur de l'éducation peut contribuer au renforcement des discriminations sexistes dans le domaine de la technologie ; comment les technologies de l'éducation peuvent aider ou entraver la situation ; et les stéréotypes masculins dans les domaines des sciences, de la technologie, de l'ingénierie et des mathématiques (STIM). Deuxièmement, nous envisageons les conséquences pour les femmes qui évoluent dans un monde du travail fluctuant, compte tenu notamment de la précarité croissante de l'emploi et des « négligences masculines » dans les environnements professionnels technologiques. Nous montrons comment la sous-représentation des femmes dans les domaines techniques alimente une boucle de rétroaction, qui accroît la discrimination sexiste dans les systèmes d'intelligence artificielle et d'apprentissage automatique. Troisièmement, nous considérons les bénéfices et les risques liés aux prises de décision automatisées dans les services sociaux et d'aide sociale. Les droits

humains des plus vulnérables sont fragilisés dans l'État providence numérique et nous proposons des pistes pour garantir l'égalité des sexes telles que la création de mécanismes de responsabilisation externes. Ce rapport se termine en proposant des recommandations politiques concrètes afin d'enregistrer des progrès pour les droits des femmes au sein de la société numérique.

RESUMEN

La revolución digital ofrece un potencial inmenso para mejorar los resultados sociales y económicos para las mujeres. No obstante, también plantea el riesgo de perpetuar los patrones de desigualdad de género actuales. Si bien existe un importante número de iniciativas, todavía persiste una considerable brecha digital de género que limita el logro igualitario de los beneficios de la transformación digital en todos los países, ya sean de ingreso bajo, mediano o alto. El informe comienza con la descripción de un marco conceptual para comprender la relación de configuración mutua entre las cuestiones de género y la tecnología. Luego se centra en tres áreas con el fin de determinar las oportunidades y los riegos de la revolución digital en los campos de la educación, el trabajo y los servicios sociales o de bienestar.

En primer lugar, examinamos de qué manera la brecha en las competencias digitales en el sector de la educación puede producir la codificación de los sesgos de género en la tecnología; de qué manera las tecnologías educativas podrían fomentar o prevenir dicha situación, y los estereotipos masculinos en los campos de la ciencia, la tecnología, la ingeniería y las matemáticas. En segundo término, analizamos las implicaciones para las mujeres en el cambiante mundo del trabajo, como son la creciente precariedad laboral y la prevalencia de varones 'por defecto' en los entornos de trabajo tecnológicos. Mostramos de qué forma la subrepresentación de las mujeres en los ámbitos tecnológicos interactúa en un circuito de retroalimentación, lo que aumenta los sesgos de género en los sistemas de inteligencia artificial y de aprendizaje automáticos. En tercer lugar, examinamos los beneficios y los riesgos de la implementación de los procesos de toma de decisiones automatizadas en los servicios sociales y de bienestar. Los derechos humanos de las personas en situación de mayor vulnerabilidad corren especial riesgo en el estado de bienestar digital. Presentamos asimismo una serie de alternativas para garantizar la igualdad de género, como por ejemplo, el establecimiento de mecanismos externos de rendición de cuentas. En el informe se concluye con una serie de recomendaciones sobre políticas concretas para promover el progreso de los derechos de las mujeres en la sociedad digital.

1. INTRODUCTION

The digital revolution brings immense potential to improve social and economic outcomes and enhance productivity growth and population well-being globally. However, despite a number of important research initiatives, interventions and policies aimed at furthering women's empowerment and gender equality within this 'revolution', a significant digital gender gap still exists, limiting the equitable realization of the benefits of digital transformation.[1] Analysis from the EQUALS Research Group, led by the United Nations University (UNU), shows that "a gender digital divide persists irrespective of a country's overall ICT [information and communication technology] access levels, economic performance, income levels, or geographic location".[2] Women are thus under-represented in the digital revolution across high-, low- and middle-income countries despite the possibilities for marshalling greater equality.

To address this digital gender divide, and harness the potential benefits of the digital revolution, much more attention needs to be paid to the social, political and economic factors that underpin the development, design and use of digital technologies, including emerging data-driven technologies such as artificial intelligence (AI) and machine learning. While the digital transformation holds out the promise of greater gender equality, at the same time it poses the risk of encoding, repeating and amplifying existing patterns of gender inequality. This paper illustrates, through an intersectional lens, how digital technologies shape, and are shaped by, gender relations and gendered power structures. Many systemic risks (and opportunities) exist for women's equality today, as do specific educational, technological and policy solutions that would mitigate these problems. In this report, we examine three substantive areas: education, work and social/welfare services. Despite promising movements towards gender equality, there is much more to be done.

1 OECD 2018b.
2 Sey and Hafkin 2019: 25.

2.

THE DIGITAL REVOLUTION AFTER THE BEIJING DECLARATION

Over the last 25 years since the adoption of the Beijing Declaration and Platform for Action, the rapid development and spread of digital technologies has been pervasive across almost every aspect of socio-political and economic life, including systems of governance, communications and structures of production and consumption. The digital revolution, broadly marking the shift from analogue to digital technologies, is characterized by technological advances ranging from smart phones, the mobile Internet and the Internet of Things (IoT), to artificial intelligence (AI) and machine learning, (big) data and social media, cloud computing and robotics. These span public and private industries including health care, commerce, education, manufacturing and finance. As such, this 'fourth industrial revolution' has brought with it a new digital economy across developed and developing economies alike.[3]

Data-driven, digital technology has changed the way people communicate, inform themselves and relate to each other;[4] it has shaped our experiences of time;[5] expanded existing and new forms of activism;[6] affected governance systems, including the ways in which public services are delivered;[7] altered production and consumption patterns with far-reaching implications for the world of work;[8] and led to the rise of 'big data' as a valuable material that is mined to support new forms of capitalist accumulation.[9] Significantly, AI, underpinned by algorithms and machine learning, has become a defining feature and driving force of this data-driven, digital revolution, as we will elaborate below.[10]

As with previous periods of rapid technological change, digitalization has provoked both utopian and dystopian visions of the future. Digital technologies could significantly improve female participation in economic life and enhance the social autonomy of women. Certain technologies offer women the potential to bypass, or leapfrog, some of the traditional cultural and mobility barriers they face offline, particularly in low- and middle-income countries.[11] For example, women unable to join the demonstrations

3 Schwab 2016.
4 Turkle 2011.
5 Wajcman 2015.
6 Friedman 2016.
7 Eubanks 2018.
8 ILO 2019.
9 Zuboff 2019.

10 OECD 2019, 2020. "While there is not a universally accepted definition of Artificial Intelligence (AI), the term is often used to describe when a machine or system performs tasks that would ordinarily require human brainpower to accomplish, such as making sense of spoken language, learning behaviors or solving problems. There are a wide range of such AI systems, which broadly consist of computers running algorithms, often drawing from data in order to accomplish their tasks" (The Alan Turing Institute 2019).
11 Sorgner et al. 2017.

during Sudan's protest movement, particularly rural women who are typically constrained by deeply rooted patriarchal structures, recorded and shared their support on social media, such as Facebook and Twitter.[12] Additionally, in Rwanda, over 3,500 women farmers are now connected through mobile technology to information, markets and finance.[13]

Yet, at the same time, there are worrying signs that the digital gender divide is widening. Hurdles include (lack of) education as well as inherent biases and socio-cultural norms located within existing (masculine) power structures that curtail women and girls' ability to benefit from the opportunities offered by the digital revolution.[14] In Saudi Arabia, for example, the Absher App has been (ab)used by men to track and control their women dependent's movements, reinforcing the country's system of male guardianship.[15]

While the Internet was initially viewed as a democratizing platform—for example, through citizen reporting of news and information sharing—such early emancipatory promises increasingly fall short as a small group of large technology corporations based in the Global North has emerged as a dominant controlling force in the new global economy. These 'tech giants' monopolize markets and wield power over digital data, as major online platforms are found complicit in the spread of misinformation, hate speech and misogynistic (and racist) online abuse and harassment.[16] In particular, there are concerns that unprecedented levels of data mining, or 'data extractivism', algorithms and predictive risk models could entrench existing inequalities and power dynamics, threaten individual rights and enable new forms of surveillance by governments and corporations.[17] This is about the danger of encoding—and amplifying—offline inequalities into online structures, as these technologies can carry over the structural inequalities and social norms of the offline world into the digital.

In sum, "digital technologies are rapidly transforming society, simultaneously allowing for unprecedented advances in the human condition and giving rise to profound new challenges. Growing opportunities created by the application of digital technologies are paralleled by stark abuses and unintended consequences."[18] Indeed, alongside the successful implementation of various technologies over the past decade, new risks and challenges related to fairness and inclusion, (data) privacy and autonomy, accountability and transparency have become increasingly clear.[19]

This paper will argue that, in order to mitigate these emerging issues, digital technologies cannot be understood as autonomous, gender-neutral tools but rather as part of a wider, socio-political context that shapes their design, purpose and use. This perspective is particularly important at a time when digital tools are often marketed as the solution to all social problems. If the generation and implementation of new technologies always involves preferences and choices, then there are opportunities to build them in ways that prevent harm and, more so, promote the 'good'. As data-driven technologies touch on almost every aspect of economic, social and political life in the 'Network Society',[20] attention must be drawn towards the ways in which these digital tools can be directed towards advancing equality, in particular women's rights in the digital age. At a moment when technology is being marshalled to make choices of global consequence, and is affecting the lives of individuals and society in ways both profound and subtle, this warrants urgent attention.[21]

12 Robertson and Ayazi 2019.
13 Mlambo-Ngcuka 2017.
14 OECD 2018a.
15 Robertson and Ayazi 2019.
16 However, promising data science initiatives such as Troll Patrol by Amnesty International are working to expose abuse towards women on Twitter.
17 Eubanks 2018; Zuboff 2019.
18 UN Secretary-General's High-level Panel on Digital Cooperation 2019: 4.
19 The Alan Turing Institute 2019.
20 Castells 1996.
21 West, Kraut and Chew 2019.

3.

THE DIGITAL REVOLUTION AND GENDER: A CONCEPTUAL FRAMEWORK

Early feminist responses to the digital revolution were largely optimistic about the potential of digital technologies, particularly information and communication technologies (ICTs), to empower women and transform gender relations.[22] Cyberspace seemed like a new gender-neutral arena; a democratizing and emancipatory platform. And, in many ways, it is. Mobile phone technologies in particular have been found to benefit women in increasing their access to information and facilitating collective action.[23]

As such, a number of initiatives and projects that focus on access to technology have been put in place to advance women's digital empowerment. For example, GSMA's 'Connected Women' programme works with mobile operators to address the barriers to women accessing and using mobile Internet, in particular mobile money services, in low- and middle-income countries.[24] Additionally, the 'Digital Gender Gaps' project aims to track progress on gender inequalities in Internet and mobile access and usage in real time, 'measuring' women's participation in the digital revolution.[25] Acknowledging the wide-ranging potential of digital technologies in these ways, the Sustainable Development Goals (SDGs) pledged to "enhance the use of...information and communication technology to promote the empowerment of women" (Goal 5b).[26]

Despite the good intentions and partial successes of these initiatives, however, inequalities in access to ICTs, and moreover men's control over women's use of ICTs, continue to persist.[27] It is estimated that women's access to the Internet and mobile phones is about 85 per cent of the level for men, on average, and that a total of 1.7 billion women in the Global South are unconnected.[28] Worldwide, roughly 327 million fewer women than men have a smartphone and can access mobile Internet.[29]

Yet, crucially, the language of 'ICTs for women's rights'—along with other initiatives that work towards women's digital empowerment—is often framed too narrowly as an 'access' issue. Along with feminist critiques of ICT4D (ICT for Development), we emphasize the need to move beyond issues of access (and affordability) to address questions of power and inequality.[30] This means, for example, attending to the potential implications for gender-responsive digital technology of the increasing concentration of economic and political power in the tech sector as well as its resistance against regulation. There is a lack of adherence to the Universal Declaration of Human Rights[31] as well as the missions of more

22 Wajcman 2004.
23 OECD 2018a.
24 Rowntree 2019.
25 Kashyap et al. 2019.
26 UN Sustainable Development Goals Knowledge Platform 2019.
27 Sey and Hafkin 2019.
28 Devillard et al. 2018.
29 OECD 2018a.
30 Tongia et al. 2005.
31 UN General Assembly 1948.

gender-specific directives such as the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW).[32] This broadly involves the ways in which gender intersects with other aspects of difference and disadvantage in the societies within which these technologies sit. For instance, women who are poor or belong to racial minorities experience the negative effects of digitalization and automation more acutely.[33] This will be acknowledged throughout the paper, and one particular example of this can be found in the digital welfare state, which will be discussed in section 6.2 below.

Moreover, many discussions of digital technologies—particularly those presented by technology developers themselves—often make technologically deterministic claims about their 'effects'. In other words, they assume that technology impinges on society from the outside, that technical change is autonomous and value-free and itself causes social change. By contrast, the social shaping approach adopted here understands technologies themselves as socially shaped, not only in their usage but also in their very design and technical content. Which technologies have been and will be developed is fundamentally shaped by the minds, hands and culture of people and, therefore, reflects history, context, choices and values.[34]

An intersectional (techno)feminist analysis, then, examines the ways in which gender power relations and gendered meanings influence the process of technological change and are inscribed into technologies. In other words, "women's identities, needs and priorities are configured together with digital technologies".[35] As much research suggests, technologies are gendered by association and by design, where 'association' refers to the gendering of work environments and to technology stereotypes.[36] In this way, 'gendered practices' mediate the digital revolution and the political and socio-economic roots of the networks that shape and deploy technological systems.

32 UN General Assembly 1979. However, promising initiatives such as the Human Rights, Big Data and Technology Project at Essex University consider the challenges and opportunities presented by AI and big data from a human rights perspective.
33 Buolamwini and Gebru 2018.
34 Mackenzie and Wajcman 1999; Felt et al. 2017.
35 Wajcman 2010: 149-150.
36 Faulkner 2001.

Feminist scholars researching at the intersection of gender and technology examine the ways in which people produce, sustain and challenge gender identity within science and technology. For example, gendered norms have been shown to shape and circumscribe scientific insights,[37] and gendered identities are found to be co-constructed with technologies and technical orientations[38]— often in connection with alignments of race and class.[39] The experience of women is not universal, and it is necessary to pay attention to intersections of gender, race, class, sexuality, ethnicity, disability and age.

If then "technology as such is neither inherently patriarchal nor unambiguously liberating" but a socially shaped crystallization of society, feminist analysis must pay attention to the economic, social and political circumstances that influence the development and use of digital technologies in the current era.[40] In this way we might realize the full potential of the digital revolution for social justice, including gender equality.[41] This era is marked by persistent poverty and rising inequalities; democratic backsliding, including reversals of progress on gender equality and women's rights; welfare state retrenchment and austerity; and the increasing power of corporations. Gender-based digital exclusion—and, indeed, inclusion—must be located within these broader structural trends and institutional changes. This in turn requires a move beyond the focus on strengthening women's access to and use of digital technologies, on the one hand, and 'getting more women in tech', on the other.

The focus should be on harnessing digital technologies for accelerating progress towards gender equality rather than perpetuating patterns of conscious or unconscious discrimination against women within the digital society. The following sections focus on three areas that illustrate how digital technologies shape (and are shaped by) gender (in) equality in order to identify opportunities and risks in the digital revolution: education, work and social/welfare services.

37 Haraway 1988.
38 Bardzell 2018; Pérez-Bustos 2018.
39 Noble 2018; Benjamin 2019.
40 Wajcman 2010: 148.
41 O'Donnell and Sweetman 2018.

4.

EDUCATION AND LIFELONG LEARNING

The rise and widespread dissemination of digital technologies shapes gender (in)equality in the educational sphere in a multiplicity of ways throughout the educational life-course. This occurs across a number of interrelated 'moments', set against a backdrop in which the pervasive structural (gender) inequalities of the offline world—growing in education systems and educational opportunities anyway, in part due to austerity measures—are being perpetuated and amplified by emerging digital educational infrastructures. These 'moments' include limited access for girls in under-developed economies to educational opportunities, both with and without technologies; gender inequalities in digital literacies (the 'digital skills gender gap') and the limited number of women in science, technology, engineering and mathematics (STEM) programmes;[42] and the 'masculine' cultural associations with a STEM education and related gendered identities, stereotypes and biases.[43]

"Certain gendered norms govern technical participation... producing continuing absences in the field."[44] This in turn reinforces gender deficits in the STEM pipeline into future technological development in the workplace, which risks further construction of biases, particularly in data-driven, decision-making technologies. A number of campaigns to involve more women in STEM, AI and data science education have recently been launched in order to mitigate these risks, and these—along with other promising measures and technologies for promoting gender equality in educational systems—will be discussed below.[45]

4.1
The digital skills gap can lead to the encoding of gender biases in technology

Once defined by inequalities in access to digital technology, the digital gender divide is now more about deficits in learning and skills. While there is still an 'access gap' between women and men, especially in the Global South, women's access to digital technologies has greatly improved over the past 25 years. At the same time, however, the gender 'digital skills gap' persists. Despite a number of important interventions and policies aimed at achieving gender equality in digital skills across both developed and developing economies, the divide not only remains large but, in some contexts, is growing wider. This skills divide is underpinned by a deficit in digital literacies among women, particularly in low- and middle-income countries, where many women lack the necessary techno-social capabilities to compete in a global online environment.[46]

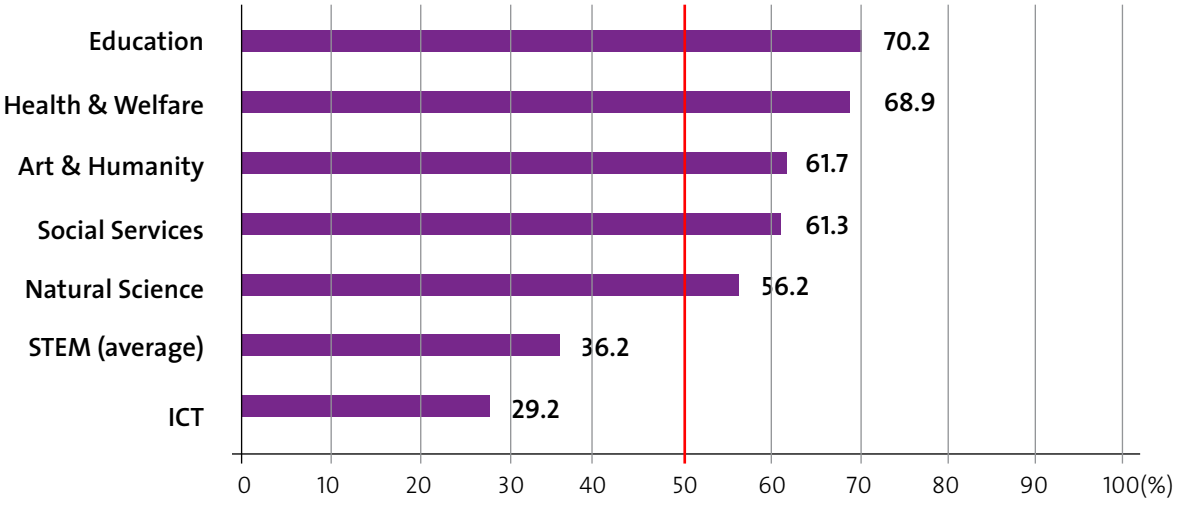
Education in gender-responsive learning environments has a key role to play in helping women and girls to develop their digital skills and gain confidence in using them. Globally, many women and girls can afford technology but do not know how to leverage it for empowerment. This is the case from the most basic levels of proficiency to the most advanced skills in frontier areas such as AI and machine learning.

42 Ertl and Helling 2012.
43 Master et al. 2016; Stoet and Geary 2018. The masculine construction of computing expertise leads to a gendered digital computing culture, shaping 'gendered spaces' across the educational life-course (as well as in the workplace) (Margolis and Fisher 2002).
44 Rosner 2019: 77.
45 Minevich 2020.
46 Gurumurthy et al. 2018.

"Women fall off every rung of this skills continuum, so that by the time learners reach the vanguard of technology creation where norms, protocols and processes are shaped, women are almost entirely absent."[47]

The skills gap widens in secondary and tertiary education, and lower proportions of women than men graduate in engineering and ICT subjects (see Figure 1).[48] Girls' relatively lower enrolment and graduation in the STEM disciplines, which would allow them to thrive in a digital world, perpetuates a cycle of widening gaps and greater inequality, especially in disadvantaged areas.

FIGURE 1.
Global proportion of female enrolments by field of study (2016)



Source: Sey and Hafkin 2019; West, Kraut and Chew 2019.

A variety of initiatives has been trialled in the past few decades in developed economies to encourage more diversity in technological fields within higher education. Particularly notable are the successful models provided by the US universities Carnegie Mellon and Harvey Mudd, which have dramatically increased the participation of women in their computer science departments. For example, Carnegie Mellon increased the number of women from 7 per cent in 1995 to 42 per cent in 2000.[49] This suggests that steps towards resolving the issues can be straightforward with the right policies and leadership in place.

In developing economies, however, the situation is more complex. Here, the social, political and economic challenges can be myriad and overlapping. Women and girls may not have the financial independence needed to purchase digital technologies (or pay for Internet connectivity), and many struggle to access public ICT facilities due to limits on their freedom of movement or unsafe roads. Moreover, "digital access, even when available, may be controlled and monitored by men".[50] But when attention is paid to the right structural factors, change can happen.[51] A recent study on women's digital literacy in Indonesia, for instance, shows that teaching women how to create content and share information on digital media can open up opportunities for economic and professional growth.[52]

47 West, Kraut and Chew 2019: 64-65.
48 Varma 2010.
49 Frieze and Quesenberry 2019.
50 West, Kraut and Chew 2019: 37.
51 Devillard et al. 2018.
52 Suwana and Lily 2017.

Concerted efforts to close the digital skills gender gap can help countries meet their international commitments to education and gender equality. Alongside gender equality (in gaining digital literacy) as a fundamental human right, learning digital skills can also impact on women's ability to participate in government and politics and engage more actively with their communities. There are also a number of economic benefits, from enabling women to enter and compete in the labour market and reducing the gender wage gap to increasing profits, productivity and innovation for technology companies. Furthermore, if women are not equipped with the necessary skills to participate in the design and development of technology, in particular AI-based educational technology, then their lack of involvement will lead to the further encoding of biases. "While many argue that the efficiencies of AI can level the playing field in classrooms, we need more due diligence and intellectual exploration before we deploy the technology to schools."[53]

Digital skills education programmes should strive not just for gender sensitivity but also for gender-transformative approaches. Education can shift the 'tech is for boys' narrative that often guides girls' and women's interests, perceptions of their own aptitude, decisions about fields of study, career paths and professional aspirations. In this regard, the EQUALS Skills Coalition, a multi-stakeholder initiative across the public and private sectors, promotes gender balance in the technology sector by championing equality of access and, more importantly, skills development. Additionally, the Global Fund for Women's Technology Initiative works towards not only 'closing the gender gap' in access to and, crucially, control and shaping of technology but also empowering women through STEM and IT education investments. The Women's Rights Online (WRO) network within the World Wide Web Foundation is also a research and advocacy network that aims to drive women's empowerment through the Internet. Digital skills and literacies are necessary—but not sufficient—conditions for women to meaningfully harness the advances in digital technologies (across the last 25 years) for their social and economic empowerment.

53 Perry and Lee 2019.

4.2 Education technologies

Technological innovations in the last few decades have altered today's educational landscape. Digital learning technologies can impact how, what and where students learn and facilitate (or inhibit) access to educational opportunities, both formally and informally.[54] Educational technology ('edtech'), including personalized distance learning platforms, educational games and online grading and rating, can be leveraged across high-, low- and middle-income countries to help women and girls navigate the digital economy in different ways.[55] Digital technologies, both software and hardware, broadly used across the education sector encompass:[56]

- For direct instruction and teaching: smartboards; interactive whiteboards
- To access materials and information: e-books; Internet-connected laptops; PCs; tablets; smartphones with apps; e-readers
- For teacher training: online courses
- For collaboration (synchronous and asynchronous): videoconferencing; forums; social networks (for example, Edmodo)
- To create a 'flipped classroom': Bring Your Own Device (BYOD) schemes
- For blended learning: blogs; wikis; podcasts; programming tools; digital cameras; scanners; digital portfolios
- For technologically enhanced classrooms: gamification; robotics; simulations; augmented reality (AR)/virtual reality (VR) (for example, zSpace)
- For online and distance learning: phones for mobile learning (m-learning); virtual classrooms; open educational resources (OERs) (for example, onebillion); massive open online courses (MOOCs); virtual learning environments (VLEs)

54 UNESCO 2015; Selwyn 2017.
55 Emejulu and McGregor 2016; Escueta et al. 2017.
56 It is important to note that, despite the way in which this 'laundry list' is organized, the same digital device can be used for different goals and purposes, and new technologies are rapidly emerging across all categories.

- For adaptive and personalized learning: artificial intelligence (AI); computer-based assessment tools; intelligent tutoring systems (ITS) (for example, Mindspark and Doodle Maths)
- For learning analytics (for example, Blackboard Data)
- For organization of education: content management systems (CMS); learning management systems (LMS)

However, implementing digital technologies in pedagogy, particularly in schools, requires a critical understanding of each country's economic, political, social and cultural climates. Additionally, growing investment in digital technologies in the education sector risks replacing investments in 'traditional' physical and human infrastructure, especially in developing economies and rural areas that may struggle with teacher shortages. The discussion of gender and education technology in this report takes place within this context.

Internet access and digital technologies can be used by women and girls for lifelong distance learning and training in low- and middle-income countries, for example. Online learning platforms have the potential to open up new opportunities to women, particularly in rural and resource-constrained environments with limited access to formal educational and training institutions. For example, 'Making Ghanaian Girls Great!' (MGCubed) is Ghana's first interactive distance-learning project. Funded by the Department for International Development (DFID)'s Girls' Education Challenge (GEC), the MGCubed Project uses solar-powered and satellite-enabled distance learning infrastructure to deliver interactive learning sessions to students, teachers, communities and government officials. Learning Equality has also created tools for low-income countries such as Kolibri, an open-source educational toolkit, and KA Lite, an offline version of Khan Academy. Additionally, Rumie, offering a low-cost and scalable education app, has launched the Mighty Girls campaign to develop its new WebApp, and the Open Learning Exchange (OLE) is building its TIGER (These Inspiring Girls Enjoy Reading) program for Syrian girls in the Za'atari refugee camp in Jordan. Additionally, in the Republic of Moldova, GirlsGoIT teaches girls digital, ICT and entrepreneurial skills and promotes positive role models through video. In adult learning, UN Women has developed WeLearn, a Virtual Skills School offering 'second chance' education for those outside the formal system and an opportunity to acquire technical and professional skills. It is important to note that while no recent, large-scale systematic review of gender, education and technology exists, individual cases such as these are promising examples of the ways in which digital tools can help promote greater gender equality in educational systems.

At the same time, while online platforms and other educational technologies have much potential, there needs to be greater awareness of how gender scripts are embedded in educational tools (by instructional designers), reinforced in classroom practices and thus shape learner experiences.[57] This is particularly the case if there are fewer women designing and developing these systems. Studies have also found gender differences in teachers' use of digital technologies across the educational life-course. For example, Zhou and Xu found that women had lower confidence in the use of computers in teaching in higher education.[58] Educational technologies can be harnessed to encourage greater gender equality through teaching and learning, but broader social relations across contexts must be understood and addressed in order to advance this.

4.3 Masculine associations with STEM and digital fields

Cultural associations between masculinity and technological skill, and a belief in femininity as 'incompatible' with technical pursuits, persist across the digital landscape.[59] The stereotype of technology and engineering as male domains is pervasive across educational contexts, affecting girls' confidence in their technical skills, shaping their perception of their

57 Heemskerk et al. 2009.
58 Zhou and Xu 2007.
59 Hicks 2017.

own identity (and proficiencies) and thus discouraging them to become involved in such fields.

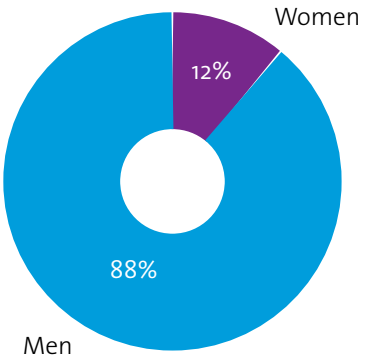
It should be noted, however, that there is some variation among nations. Stoet and Geary discuss a 'gender-equality paradox' that suggests the more gender equality in a country, the fewer women in STEM fields.[60] Indeed, Arab countries have between 40–50 per cent female participation in ICT programmes (a proportion far higher than many of the more gender-equal European countries),[61] and there are large numbers of women in computer science in Malaysia since it is not deemed 'masculine' in the culture and is considered to provide good careers for women.[62] However, these examples are not representative of the broader trends worldwide.

The social construction of digital expertise in particular leads to a gendered computing culture, shaping 'gendered spaces' across the educational life-course.[63] Gendered norms and (sub)conscious biases govern technical participations and absences in STEM and ICT education, which in turn reinforces gender deficits in the STEM pipeline into future technological development in the workplace.[64] The limited number of women in educational STEM programmes, as presented above, is underpinned by this stereotyping of 'what it takes' to be successful across the technical educational life-course in a digital world.[65]

There are, however, a growing number of organizations working to promote gender equality in education and technology, including WISE, Athena SWAN, Black Girls Code and Girls who Code. Despite a range of exciting initiatives, there is nevertheless a lack of coherent policy promoting the participation of women and girls in technology across the educational landscape. This impedes formal training and institutional mechanisms for the advancement of women in STEM education and, in turn, exacerbates the deficit of women in academia researching in technical fields. For example, a joint study by WIRED and Element AI found that only 12 per cent of authors publishing in the leading three AI conferences in 2018 were women (see Figure 2).[66] Our own research at The Alan Turing Institute also found that women are under-represented at 17-18 per cent across the growing online data science development platform communities such as DS Central, Kaggle and OpenML. A large-scale analysis of gender diversity in AI research using publications from arXiv found a severe gender diversity gap in AI research.[67] Going forward, changing pervasive gender stereotypes and hierarchies can help to counter inequalities across the educational life-course, ensuring that digital technologies foster equality instead of becoming further assimilated into the dominant structures of power within education, and beyond.

FIGURE 2.

Contributions to the top three AI conferences in 2018



Source: Mantha and Hudson 2018.

60 Stoet and Geary 2018.
61 West, Kraut and Chew 2019.
62 Lagesen 2008.
63 Margolis and Fisher 2002.
64 Phipps 2007.
65 Hill et al. 2010.
66 Mantha and Hudson 2018.
67 Stathoulopoulos and Mateos-Garcia 2019.

5.
WORK

The digital revolution holds the promise of greater gender equality in education, while at the same time posing the risk of amplifying existing patterns of gender inequality. This is also the case in the world of work. The discussion of education above set the scene for the 'pipeline problem' of getting women 'into' the technology labour market in order to move towards women's equality in the digital revolution. But education on its own will not solve the problem: Stereotypes and gendered spaces, shaped by (and shaping) gender power relations and associations in the educational sphere, are brought forward—and often magnified—in the workplace.

This not only reduces opportunities for women to harness the digital revolution for their empowerment but also risks widening the digital gender divide as corporate technology giants increasingly dominate the new global economy. The structural inequality of opportunity for women in the workplace, severely limiting their participation in the design and development of new digital technologies, is part of a feedback loop that further reproduces biases against women. As we shall see, this process is magnified in emerging AI systems, through both the oncoming wave of AI technologies automating existing job roles (and the need for women to re-skill into new careers) and the presentation of these technologies as 'objective' decision-making tools.

5.1 The workplace

There are notable disparities in the gender diversity of technological workforces across Organisation for Economic Cooperation and Development (OECD) countries. For example, in 2014 it was found that, as a percentage of all male and female workers in Finland, just under 10 per cent of men were ICT specialists compared to only around 2 per cent of women (OECD 2017). Gendered divisions of labour around technology are, as previously noted, based in part on equations around masculinity and technical skill. However, the masculine culture of the workplace itself is a key factor in women's under-representation in technological pursuits. In particular, stereotypes about digital technical skills, including the 'brogrammer'[68] and 'geek' cultures synonymous with Silicon Valley, hinder women's career progression.[69]

Several studies have revealed subtle cultural practices embedded within technology workplaces that lead to 'chilly' workplace climates for women and minorities.[70] The prevalence of 'masculine defaults' in these spaces results in micro-aggressions, subconscious biases, sexual harassment and other forms of discrimination such as demeaning comments.[71] For instance, in 2018 Google staff walked out over how sexual misconduct allegations were being dealt with at the firm.[72] More recently Alphabet, the parent company of Google, rejected several proposals at its annual shareholder meeting to address sexual harassment and boost diversity.[73] Awareness of these issues alone does not necessarily lead to corporate (or governmental) policy changes.

In turn, this 'technoculture' has significant repercussions for recruitment, promotion, career trajectories and pay. For example, Wynn and Correll suggest that

68 A combination of 'bro' (short for brother) and 'programmer'.
69 Jacobs 2018.
70 Hill et al. 2010; Berman and Bourne 2015.
71 Alfrey and Twine 2016.
72 Lee 2018.
73 Paul 2019.

women are alienated at the point of recruitment into technology careers.[74] They found that company representatives often engage in behaviours, such as geek culture references, that create unwelcoming environments for women prior to joining a firm. Additionally, there is a significant pay gap in technology fields: In the United Kingdom, for example, it is estimated to be 16.8 per cent. Furthermore, once women are employed in technological fields, the rate of attrition is high. A 2016 study from the US National Centre for Women and Information Technology found that women leave technology jobs at twice the rate of men.[75] In a similar vein, McKinsey found women made up 37 per cent of entry-level roles in technology, but only 25 per cent reached senior management roles and 15 per cent made executive level.[76]

There is also a severe under-representation problem in entrepreneurship. This, almost paradoxically, is often heralded as the way for women to 'get ahead' in the digital revolution. Female founders in the United States received only 2 per cent of venture capital (VC) dollars in 2017, according to data from VC database PitchBook.[77] Atomico also found that 93 per cent of all start-up funds raised in Europe in 2018 went to all-male founding teams—with just 2 per cent to all-female founding teams. However, there are now some examples of funds, such as Diversity VC, that focus on women and minorities.

Recently, women and other marginalized groups have been making inroads back into computer science in professional capacities. However, the same patterns that presented themselves in the earliest days of the field may be about to occur again. At the advent of electronic computing following the Second World War, software programming in industrialized countries was largely considered 'women's work', and the first 'computers' were young women.[78] As computer programming became professionalized, however, the gender composition of the industry shifted, marginalizing the work of female technical experts by fashioning them into a technical 'underclass'.

As women have begun to enter certain technological subdomains in more recent years (often through boot camps and other atypical educational pathways), these fields have started to lose prestige and experience salary drops.[79] Meanwhile, men are flocking to the new (prestigious and highly remunerated) fields of data science and AI. This annexing of prestige fields, at the frontiers of technological development, is closely related to the gender pay gap[80] and the prevalence of men in decision-making spaces in technology companies. As Hicks notes, "throughout history, it has often not been the content of the work but the identity of the worker performing it that determined its status".[81] Building on the work of Rossiter,[82] she explains that tech has not always been associated primarily with men, and that in many cultures the association evolved as tech became a sector that was more associated with power and money.[83]

In these ways, the lack of women in the high-tech sector, particularly in leadership positions, risks perpetuating gender inequalities. A recent UN Women publication suggests that "gender-inclusive industrial policies can help ensure that women maintain access to these jobs as they get better, on both the demand and supply sides".[84] On the demand side, such interventions would create incentives for firms to employ women or support women's leadership and voice in industry. On the supply side, ensuring women's inclusion in efforts to enhance learning and capabilities in industrial sector activities is key.

74 Wynn and Correll 2018.
75 Ashcraft et al. 2016.
76 Krivkovich et al. 2016.
77 Zarya 2018.
78 Abbate 2012.
79 Posner 2017; Broad 2019.
80 Lordan 2018.
81 Hicks 2017: 16.
82 Rossiter 1993.
83 Hicks (2017) explains that women were the largest trained technical workforce in the computing industry during the Second World War, but that Britain lost its early dominance in computing by systematically discriminating against its most qualified workers: women.
84 Elson and Seth 2019: 93.

Initiatives for professional women in technology across high-, middle- and low-income countries, such as Women in Technology Uganda (WitU) and Women Who Code, have been established to encourage women's inclusion in the technological workforce. Such drives, alongside labour force policies, are needed to ensure that conscious and unconscious biases and inequalities in the workplace do not shape the technologies constructed within these spaces, further assimilating them into dominant, masculine power structures.

5.2 The changing contours of work

To this point we have focused on women's position in the ICT sector because this is predicted to be a major growth area in the future. However, the implications of the fourth industrial revolution for gender equality in employment are far wider. There is currently much debate but little consensus about the impact of automation, and in particular the spread of AI technologies, on the number of jobs that will be created versus jobs lost. In terms of overall numbers, McKinsey predict that globally 40 to 160 million women (and a comparable number of men) may need to transition between occupations by 2030.[85] On average, across all industries, it seems that women and men are exposed to similar risks of automation.[86] Nevertheless, current differences in their position in the labour market and in the distribution of unpaid work are likely to result in gender-specific impacts.

In Europe, for example, women are particularly vulnerable to changes in the public sector and private services such as retail, whereas men are vulnerable to changes in manufacturing and construction.[87] To date, however, the overall share of female employment has remained the same. In many countries, women predominate in clerical support and health care, and while the former is shrinking the latter is fast growing. In order to adapt to the evolving digital economy and make the transition to new jobs, economists have emphasized the need for workers to be skilled and educated, mobile and tech-savvy. But long-established barriers will make it harder for women to take advantage of the new opportunities. Women generally have less time to reskill or search for employment because of their unpaid care work; are less mobile (due to physical safety and infrastructure); and have lower access to digital technology and capabilities than men. In order to address these barriers, government and industry will need to invest in training programmes for women to gain the necessary skills; develop infrastructure and networks that enhance women's mobility; and raise women's access to and knowledge of technology.[88] A concrete, practical way that governments could improve women's flexibility and ease their double burden would be thorough subsidized maternity and parental leave and childcare.

Alongside transformations in the occupational and sectoral composition of jobs, digitalization is reconfiguring the employment relationship. This too is consequential for gender equality. The rise of the 'gig' or 'platform' economy during the past decade marks a shift in the labour market.[89] Automated systems have facilitated a major expansion of one-off contracts for specified services and tasks, particularly through online platforms such as Amazon Mechanical Turk (MTurk) and Upwork. This change has implications for women as they are disproportionally employed in non-standard forms of employment and self-employment. Whether in the Global North or Global South, this 'precarious' labour is highly unregulated and is characterized by low and intermittent pay, unpaid time spent searching for tasks and exclusion from social protection and employment standards. As work becomes more fragmented, there is also increased competition for each new task.

Workers providing services on online platforms are mostly located in low-income countries. While much attention has focused on the growth of highly paid professional jobs in AI, robotics and data science, less acknowledged is the dependence of 'smart' AI on a vast, 'invisible' human labour force: those who carry

85 Madgavkar et al. 2019.
86 OECD 2018b: 23.
87 Howcroft and Rubery 2018.
88 Madgavkar et al. 2019.
89 Wood 2020.

out skilled technological work such as labelling data to feed algorithms, cleaning code, training machine learning tools and moderating and transcribing content.[90] For example, mostly invisible by design, more than 100,000 commercial content moderators evaluate posts on social media platforms, actively screening and removing offensive material.[91] These 'ghost workers', often women in the Global South, are underpaid and undervalued. Lacking labour laws, the majority of this 'unseen' workforce have no health benefits and can be fired at any time for any reason, or none.

The growth of platform-based work may appear to be gender neutral or indeed benefit women by providing increased flexibility for those with care responsibilities. However, research has revealed a persistent gender gap in both participation and pay. A worldwide survey of 'crowdwork'[92] conducted by the International Labour Organization (ILO) found gender differences in the propensity to do this work.[93] In developing countries, the gender balance is particularly skewed with just one out of five workers being a woman. The gender balance also varied by platform and country, as shown in Figure 3. It has been noted that the overall gender balance of crowdworkers across a number of platforms in 2017, including AMT US and AMT India, was uneven, with only one out of every three workers being a woman.[94]

Recent studies have also documented a gender pay gap among online platform workers. In Ukraine, which ranks first in the world in 'IT freelance' platform work, men earn 2.2 times more than women, a gap that is considerably higher than in the Ukraine offline economy.[95] This gap can be largely explained by strong occupational gender segregation, as IT specialists are predominantly male and oriented to more lucrative foreign markets. A study of the global platform Application Programming Interface found that women's average hourly rates were significantly lower than men's "when considering the same tasks, despite similar levels of educational attainment, feedback score, and length of experience".[96] More surprising, perhaps, is the 7 per cent gender earnings gaps that emerged in a recent study of over a million Uber drivers in the United States.[97] The authors argue that this gap can be attributed to three factors: experience on the platform (learning-by-doing), preferences over where to work (driven largely by where drivers live and, to a lesser extent, safety) and preferences for driving speed. While the type of work is as various as the range of explanations provided, the overall pattern suggests that gender inequality is embedded in the operation of digital platforms. Given the evidence to date, there is no reason to expect the 'gig' economy to close the gender gap.

To date, there have been several initiatives to encourage platforms and clients to improve working conditions. These include Turkopticon, a third-party website and browser plug-in for the Amazon Mechanical Turk (AMT) platform, which allows workers to rate clients who post tasks; the Oxford Internet Institute's Fairwork Foundation, which certifies online labour platforms to improve the welfare and job quality of digital workers, highlighting best and worst practices in the platform economy; and the Crowdsourcing Code of Conduct.[98] Alternatives such as state-owned platforms could offer minimum guaranteed hours or income, including financial compensation when work is not available at contracted times.[99] Adequate regulation is essential to ensure that online platforms provide real opportunity rather than substituting a traditional 'sweat shop' for a digital one.

90 Gray and Suri 2019.
91 Roberts 2019.
92 Work outsourced to a geographically dispersed crowd.
93 Berg et al. 2018.
94 Berg et al. 2018.
95 Aleksynska et al. 2018.
96 Renan Barzilay and Ben-David 2017: 420.
97 Cook et al. 2019.
98 Berg et al. 2018.
99 Howcroft and Rubery 2018.

FIGURE 3.

Top 10 employer and provider countries on Upwork, 2014

Notes: Upwork is one of the leading global freelancing platforms. Top 10 employer (provider) countries are denoted by their flags and two-digit international codes. Circular arrows denote flows where employer and provider countries coincide.

Source: OECD 2017.

5.3 AI feedback loops: The amplification of gender bias

AI is beginning to affect almost every aspect of our daily lives, and algorithms have the potential to influence key decisions around public spending, the workplace and society. Yet there is a troubling under-representation of women and minorities employed in the sector, whether designing or developing AI and machine learning systems.[100] Most digital technologies, including AI systems, are designed by the few for the many, and as such there is a serious risk that they are consolidating existing, often invisible, power dynamics (see Figures 4-6). As the European Commission has emphasized: "Technology reflects the values of its developers, and that of the information they draw from. It is clear that having more diverse teams working in the development of such technologies might help in identifying biases and prevent them."[101] The lack of diversity in the technology industry and the (resulting) emerging constructions of gender bias, particularly in algorithms and other systems produced within the field of AI, are thus deeply intertwined.

Bias can enter AI systems at various stages. First, the data used to train machine learning algorithms may under-represent certain groups or encode historical bias against marginalized demographics.[102] Second, there may be biases in the modelling process due to poor assumptions or decisions made by developers, either reflecting their own biases or resulting from a lack of understanding of the underlying data.

100 Leavy 2018.

101 Quirós et al. 2018: 11.

102 This 'gender data gap' is the failure to collect data on women, that is, gender-disaggregated data. As Criado Perez (2019) explains, this directly jeopardizes women's health and safety: Heart failure trials, historically based on male participants, result in women's heart attacks being misdiagnosed; and seats belt designs based on the male body result in women being more likely to be seriously injured in car crashes. See also D'Ignazio and Klein 2020.

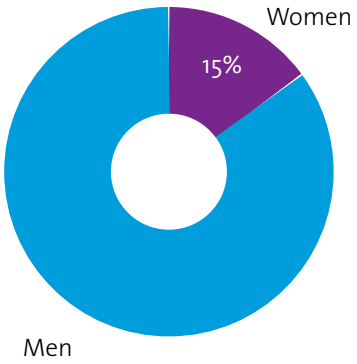
Finally, the misinterpretation of modelling results may lead to decision-making bias in processes that are based on algorithmic outcomes. Bias introduced at any one stage of the modelling process may be propagated and amplified by knock-on biases, since the results of one round of modelling are often used to inform future system design and data collection.[103]

The underlying problem is that AI systems are presented as objective and 'neutral' in decision-making rather than as inscribed with masculine preferences and values. "The diversity crisis in the industry and the problems of bias in AI systems are interrelated aspects of the same issue."[104] Machines trained using datasets generated in an unequal society tend to amplify existing inequities, turning human prejudices into seemingly objective facts. A 'feedback loop' is shaping the AI industry and its tools, and thus a gendered vision of the world is being built into AI technologies.[105]

Examples of gender-biased machine learning and AI have emerged across many different algorithms and applications, from word embeddings trained on Google News articles that label computer programmers as male and home-makers as female[106] to Apple Card assigning a woman a lower credit limit than her husband who possessed a worse credit score.[107] However, these instances of bias have not gone unnoticed, and as the use of AI and algorithmic decision-making has expanded, so has the presence of academic and policy-focused work aimed at highlighting and mitigating the potential harms of these systems.[108] Much of this work has emerged from woman-led programmes and institutions, building on intersectional feminist scholarship. In the remainder of this section, we will highlight three domains in which biased AI has arisen along with successful feminist responses in each of these areas.

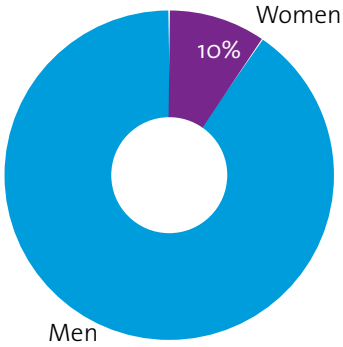
103 Mehrabi et al. 2019.
104 West, Whittaker and Crawford 2019: 3.
105 If primarily white men are setting AI agendas and developing AI tools, it follows that supposedly 'neutral' technology and data are bound to be inscribed with masculine preferences (Zou and Schiebinger 2018).
106 Bolukbasi et al. 2016.
107 Patel 2020.
108 For example, the University of Washington's Tech Policy Lab's Diverse Voices method provides a toolkit for engaging experts from under-represented groups to provide feedback on draft technology policy documents.

FIGURE 4.
Facebook's estimated AI workforce



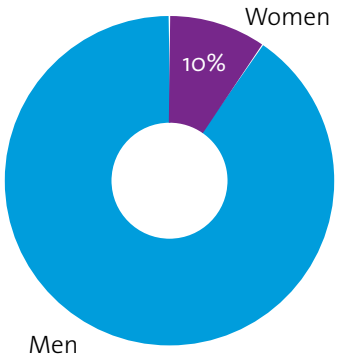
Source: Simonite 2018.

FIGURE 5.
Google's estimated AI workforce



Source: Simonite 2018.

FIGURE 6.
Global AI workforce based on LinkedIn data



Source: World Economic Forum 2018

Within the labour market, algorithmic bias has been identified in a hiring algorithm developed by Amazon, which was found to discriminate against female applicants[109] and in gendered marketing algorithms that are more likely to show science career job advertisements to men than to women.[110] The introduction of automated bias in STEM hiring is particularly concerning, as the fewer the number of women employed within the AI sector, the higher the potential for future AI systems to exhibit masculine defaults and gender bias.[111] Recognizing the need for greater workplace gender equality, a number of practical AI-based solutions have been developed, including #MeTooBots that flag communications between employees that may contain harassment,[112] Humu's 'nudge' software that dynamically suggests more inclusive behaviours to employees, and Diversio's matching of inclusion policies to companies' needs based on automated analysis of their internal diversity and employee feedback.[113] Such initiatives are crucial if the tech industry is to tackle its diversity crisis and counteract the biases and norms currently being inscribed into the systems it produces.

The common female gendering of virtual personal assistants (VPAs), such as Alexa and Siri, is another case of biased design in the sphere of AI. While developers justify this by citing 'likeability', traditional stereotypes about the role of women as obedient, subservient and 'domesticated' are further entrenched.[114] However, following the release of a report by the United Nations Educational, Scientific and Cultural Organization (UNESCO) on this subject,[115] some firms are developing gender-neutral voice assistants inspired by initiatives such as F'xa at Feminist Internet, which is intended to raise awareness about bias in AI voice systems.[116] By challenging and exposing the potential for VPAs to exacerbate existing gender stereotypes, feminist scholars have raised awareness of this issue within the tech industry and it is now beginning to be addressed.

Finally, bias is evident in computer vision technologies, both in automated image labelling and in facial analysis systems. Research has shown that when image-recognition software was trained on sets of photos that displayed gender bias—in this case, a disproportionate representation of women cooking and men playing sports—the software not only mirrored but amplified this bias, creating a stronger association between gender and activities than was found in the original photo set.[117] Further gender-biased AI has emerged in facial identification systems that successfully 'see' the faces of white men but fail to recognize the presence of dark-skinned women.[118] As a result, Buolamwini of the MIT Media Lab launched the Algorithmic Justice League (and the Gender Shades project) to promote the development of equitable and accountable AI. A host of other research bodies, including the AI Now Institute, Data & Society and the Partnership on AI,[119] have likewise emerged to study and develop policy regarding ethical and equitable AI, including in the domain of computer vision. These initiatives have significantly increased awareness and media coverage of issues surrounding biased AI, with promising results. For example, Google's Cloud Vision API will no longer identify photos and label them with gender descriptions, in alignment with the company's 'Artificial Intelligence Principles'.[120] The state of California has banned the use of facial recognition software in policing until at least 2023, and similar legislation is being debated in a number of other jurisdictions.

In addition to the initiatives outlined above, an entire field of technical debiasing has grown within the AI community that attempts to remove algorithmic bias by pre-processing the training data or applying constraints to the algorithm or its output.[121] The main limitation of this field is that a mathematical

109 Dastin 2018; ILO 2019.
110 Maron 2018.
111 Perversely, Sánchez-Monedero et al. (2020) found that automated hiring systems that claim to detect and mitigate bias obscure rather than improve systematic discrimination in the workplace.
112 Woodford 2020.
113 While not AI-based, the VMware Women's Leadership Lab at Stanford has produced a comprehensive tool for diagnosing organizational bias: See Bias | Block Bias.
114 Saran and Srikumar 2018; Adams and Ni Loideain 2019.
115 West, Kraut and Chew 2019.
116 Yates 2020.
117 Simonite 2017.
118 Raji and Buolamwini 2019.
119 A curated list of institutions and initiatives researching and combating bias in AI is available through the resources section of The Alan Turing Institute's Women in Data Science and AI hub page at turing.ac.uk/WiDSAI.
120 Beasley 2020.
121 FAT: Fairness, Accountability and Transparency in Machine Learning.

definition of fairness must be agreed before applying algorithmic debiasing techniques. Consequently, such methods are prone to shortcomings such as overlooking intersectionality and not accounting for 'context fairness' (the idea that fairness is a property of the use of a test, rather than of the test itself).[122] Even more fundamental, however, is the inability to agree on a universal definition of fairness or discrimination, with different notions being mathematically incompatible in the general case.[123] This issue is, in fact, a longstanding one in the feminist literature, with the inconsistent principles of equal opportunity (for individuals) versus equal outcomes for groups informing competing theories of gender equality.[124]

The fact that there is no single definition of fairness and that statistical fairness does not equate with equitable algorithmic use means that the question of fairness in AI is intrinsically a political and policy issue. But this does not preclude opportunities for algorithmic debiasing and explanation.[125] At their best, technical definitions of fairness and debiasing approaches function as toolkits that allow a suite of different metrics and algorithms to be applied in different contexts, accommodating multiplicity and nuance in approaches to debiasing.[126] However, knowing how, when and why to use different debiasing techniques can be challenging, and the burden of making these decisions is predominantly placed on developers.

In order to address algorithmic bias, we need a gender-balanced and diverse body of AI professionals, representing a wide range of cultural backgrounds and experience that can inform concepts of fairness and ethical systems. As it is, the limitations of the AI sector are being 'hard-coded' into digital technology products. The Lords AI Committee in the United Kingdom advocates increasing gender and ethnic diversity amongst AI developers to tackle this.[127] It is also essential that the ethics of design include intersectional gender issues to "ensure that Artificial Intelligence is a field that is inclusive by design".[128] The Gendered Innovations project, for example—arguing that gender analysis needs to be part of research and development design—seeks to develop methods of sex and gender analysis for scientists and engineers. This includes elements such as user testing and the customer journey, that is, a 'story' created to help better understand users' behaviour.[129] Shaping emerging AI systems, platforms and tools in such ways can contribute to advancing women's rights and gender justice in the digital age.[130]

122 Foulds et al. 2019.
123 Hutchinson and Mitchell 2019.
124 Phillips 2006.
125 As AI becomes ubiquitous in decision-making processes, a movement has grown arguing that such systems should be explicable to their human users to enable meaningful challenges to system outcomes. While extracting a single, definitive explanation from an AI system is a complex process, steps have already been taken in European law— the General Data Protection Regulation (GDPR)—to codify the rights to some form of explanation when such systems are used.
126 Bellamy et al. 2018.
127 House of Lords Artificial Intelligence Select Committee 2017.
128 WEF 2018: 32.
129 Gibbs 2020.
130 There is also a global 'AI repository' to identify AI-related projects, research initiatives, think tanks and organizations that can accelerate progress towards the 17 SDGs. Examples include Gender Gap Grader and Tech She Can.

6. SOCIAL AND WELFARE SERVICES

The introduction of digital technologies into the public sector, in particular into social protection and welfare systems, coincides with a prolonged period of austerity in place since the 2010s. This includes attempts to cut back and 'rationalize' welfare rather than expanding it. In parallel, women are disproportionately more likely to be in need of public social services due to their greater care and domestic responsibilities. Indeed, marginalized people, most prominently women in deprived areas across the world, are most reliant on welfare services. As such, it is crucial to examine the implications of the digital revolution on gender (in)equality across public sector systems.

In developed economies in particular, the digital revolution has brought with it data-driven, automated systems (based on predictive models) that make decisions regarding social services such as, for example, who should receive state welfare payments. AI is now used to automate decision-making from the health-care industry to the legal system and may be responsible for "making choices that affect people's life trajectory, such as which medical treatment they receive [or] whether they are eligible for life insurance or a loan".[131] Digital technologies are increasingly enmeshed in social policy and service delivery, especially for society's disadvantaged, augmenting operations of welfare payments, homeless services and family support and child protection services. It is thus important to explore not only the potential benefits of digital technology and automation for gender equality but also possible problems and challenges. In this way optimal pathways can be mapped for fostering equality through digital social and welfare services, such as social protection and financial welfare systems, going forward.

6.1 Potential benefits of digitalization and automation for gender equality in social protection

In the Global South, there are a number of ways in which the digital revolution is nurturing gender equality in social and welfare systems. For example, a study of the digital governance Aadhaar platforms in the Krishna district of Andhra Pradesh (which allows the government to biometrically identify recipients of social services and subsidies including social pensions), found that women expressed stronger preferences relative to men for the consistency of digitally delivered benefits.[132] It also found that women appreciated the increased control over their benefits, augmenting their agency over entitlements and subsidies. Furthermore, a study on mobile phone ownership and usage by women in India, using 2004-2005 National Family Health Survey cross-sectional data, concluded that households where women had mobile phones reported lower tolerance for domestic violence and higher women's autonomy in mobility and economic independence.[133]

131 West, Kraut and Chew 2019: 33.

132 Gelb et al. 2018.

133 Bhowmick 2018.

There are also palpable benefits for gender equality stemming from the application of AI and automation in social and welfare services, the most promising of which being the potential for eliminating human bias in such systems. In Automating Inequality, Eubanks discusses how human bias in public sector services has created deep inequalities for decades.[134] As such, automated decision-making by AI systems presents an opportunity for circumventing any biased opinions held by people making the judgements in social services. However, as Eubanks also cautions, "these systems don't actually remove that bias, they simply move it".[135]

6.2 Risks and challenges in the implementation of the digital welfare state

Automated eligibility systems and predictive analytics can embed, reproduce and reinforce gender, class and racial distinctions within what is presented as an 'objective' automated tool. Even if designed with the best of intentions, they "do not remove bias, they launder it, performing a high-tech sleight of hand that encourages users to perceive deeply political decisions as natural and inevitable".[136] As touched on above, when deep learning systems are trained on data that contain gender biases, these biases are reproduced in the software. Yet they are presented as 'neutral' decision-makers. Fei-Fei Li, a prominent Stanford researcher in the AI field, describes such systems as "bias in, bias out".[137]

In his 2019 report, the Special Rapporteur on extreme poverty and human rights explores the uses of digital technologies, AI and automation in the welfare state, including in eligibility assessment and welfare benefit calculation, and how these technologies can be used for social protection going forward, protecting human rights in the 'digital welfare state'.[138] Yet he explains that while government is increasingly automating itself with the use of data and AI, evidence suggests that the human rights of the most vulnerable are especially at risk in such contexts. One example of this can be found in badly designed payments mechanisms for social protection programmes (which provide cash transfers such as pensions or child benefits), harming the very beneficiaries they are meant to help. This is frequently due to their outsourcing to third-party payment service providers, who often do not value data protection and reasonable excess fees, for example—in other words, they fail to take a human rights approach.[139] The Special Rapporteur warns of a "digital welfare dystopia" where the digitization of welfare systems, purported to benefit citizens, in fact promotes reductions in welfare spending and imposes intrusive government surveillance systems, potentially to the benefit of the private sector.[140]

A major problem is the lack of transparency on the part of big technology companies as well as digital public services.[141] Consequently, algorithms widely used in determining life-affecting circumstances are often black-boxed; that is, they are opaque to social and welfare recipients, "their workings invisible to all but the highest priests in their domains: mathematicians and computer scientists."[142] As Powles rightly argues, we need genuine accountability mechanisms, external to companies and accessible to populations.[143]

6.3 Pathways for ensuring gender equality in digital social and welfare services

It is crucial for a human rights-centred approach to underpin the development and implementation of digital and automation technologies in social and welfare services in order to ensure gender equality in their application. Within this, some attempts to counter the risks and challenges in implementation of the digital welfare state focus on gender data gaps. These include work by Criado Perez who, in *Invisible Women*,

134 Eubanks 2018.
135 Ibid.
136 Ibid: 224.
137 Hempel 2018.
138 Alston 2019.
139 Kidd and Langhan 2019.
140 Alston 2019: 19.
141 Vaidhyanathan 2011; Brennan 2019; Clement-Jones 2020.
142 O'Neil 2016: 3.
143 Powles 2018.

shows how the world is designed for men, even going beyond digital issues, with examples of why we need to better integrate gender in innovation cycles;[144] the Inclusive Data Charter (IDC), which advocates for more granular data to understand the needs and experiences of the most marginalized in society; UN Women's Women Count programme, which "seeks to bring about a radical shift in how gender statistics are used, created and promoted"; and the Data2x project, which aims to improve the "quality, availability, and use of gender data in order to make a practical difference in the lives of women and girls worldwide". Similarly, the Gender Innovation Principles, created by UN Women and the Global Innovation Coalition for Change (GICC) in 2018, set standards to guide any organization focused on making the innovation market work better for women. These cover, for instance, how to include women and thus women's rights in innovation design thinking (for example, including women as the end users).

Furthermore, prioritizing women's digital literacy by combining mobile technology with the array of existing welfare programmes targeted at them can potentially empower women. Widening access to mobile banking in Africa, for example, could significantly increase women's independence.[145] Pande and Schaner proposed the adoption of mobile phone-enabled check-ins for a conditional welfare programme, presenting the hypothetical example of a scholarship for girls received only by those who can verify their attendance at school via the phone.[146] Integrating benefits targeted to the poorest women in the Global South in this manner could be a promising way to make welfare programmes fairer and more effective for women. In these ways, opportunities can be harnessed to shape digital technology in ways that prevent harm and instead contribute to advancing gender equality and women's rights in the digital age.

144 Criado Perez 2019.

145 The Gates Foundation has warned that digital technology, in particular mobile banking, could bypass millions of women in Africa (Wintour 2019).

146 Pande and Schaner 2017.

7.

POLICY RECOMMENDATIONS FOR LEVERAGING DIGITAL TECHNOLOGY TO ADVANCE GENDER EQUALITY

Despite the range of initiatives that have been implemented since the adoption of the Beijing Declaration and Platform for Action, there is still a lack of coherent policy on promoting the participation of women in the digital revolution. Digital technologies can provide new opportunities for women's empowerment, but technology on its own cannot address the systematic problems driving the digital gender divide. The focus needs to be on concrete policy actions fostering women's and girls' full participation and inclusion in the digital revolution, while at the same time addressing ingrained stereotypes, practices and norms that lead to discrimination and even violence against women.[147] There is no one solution to closing the gender digital divide. Gender inequality stems from multiple intersecting economic, social, political and cultural barriers, and remedies must be grounded in evidence about which barriers are in play across different contexts.

1. **Governments should ensure that new technologies are developed within a regulatory framework that prioritizes, protects and promotes women's human rights.** Digital technologies pose human rights and thus women's rights issues in new and critical ways. Governments and companies should comply with human rights laws in the design, development and use of technology. A notable example of how to do so can be found in the Human Rights, Big Data and Technology Project, which considers the challenges and opportunities presented by AI and big data from a human rights perspective.[148] Any new (inter)national legal-institutional frameworks put in place to protect women's rights must be clear and enforceable. These frameworks should also be made accessible to members of the public, so that all relevant stakeholders can understand their rights and be able to hold individuals, companies and organizations accountable for fulfilling their corresponding obligations.

147 OECD 2018a.

148 See footnote 3 of this report.

2. **Ethical frameworks for auditing, monitoring and governance of (AI) technologies must put gender equality at their core.** Feminist scholarship and insights as well as input from stakeholders with lived experience of gender bias should inform ethical frameworks. For example, national AI ethics councils should audit algorithms for (intersectional) gender bias before they enter the market and, when possible, they should engage affected individuals and under-represented social groups to better understand, from a first-hand perspective, the possible impacts of the use of such algorithms. A promising initiative is the Tech Policy Lab's Diverse Voices method, which provides a toolkit for engaging experts from under-represented groups to provide feedback on draft technology policy documents.

3. **Gender analysis must be an integral part of technological investment, research and design.** Gender advocacy must include mandating for responsible gender-sensitive design and use of machine learning models. An example of this approach is the Gendered Innovations project, which aims to develop methods of gender analysis for scientists and engineers in research and development.[149] This, in turn, requires tech companies to be more accountable and transparent with respect to their collection and deployment of big data.

4. **National governments must tackle the gender data gap, both in terms of quantity and quality, while maintaining privacy and data protection as the highest concern.** International organizations should initiate research and advocacy programmes such as the Inclusive Data Charter (IDC), Women Count and Data2x.[150]

5. **Universities, schools and other educational institutions must develop the advanced technical skills and digital literacy of women and girls so that they can reap the benefits of the digital revolution.** Investment in compulsory education and digital skills for girls aimed at narrowing the digital gender divide is particularly urgent in developing economies. Women must have access to training, re-skilling and job transition pathways, especially in frontier fields such as data science and AI.

6. **Education and training on women's rights-compliant technology is needed for those designing, developing and using AI in decision-making.** This is extremely important in public policy sectors such as welfare and social protection, on which women and society's most vulnerable are particularly dependent. Public education on the lack of normative neutrality in AI and machine learning systems is also key.

7. **Policymakers must examine exclusionary practices and language, encourage men to become strong allies and promote women role models and mentors in STEM.** Women and other minorities must be actively inspired and enabled to become equal partners in technological design, development and implementation teams and practices.

8. **Companies, particularly in the tech sector, must incorporate gender mainstreaming in human resources policy so that women and men are given equal access to well-paid jobs and careers.** Actionable incentives, targets and quotas for recruiting, retaining and promoting women at work should be established, as well as ensuring women's equal participation in leadership roles.

9. **Policymakers must develop gender-inclusive labour market policies, such as paid maternity/parental leave and affordable childcare.** This would ensure that women's disproportionate responsibility for domestic and care work does not inhibit their ability to participate in the digital economy on an equal footing to men.

149 See section 5.3 above.
150 See section 6.3 above.

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