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THE DIGITAL SKILLS CRISIS: ENGENDERING TECHNOLOGY–EMPOWERING WOMEN IN CYBERSPACE

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Abstract:
This paper examines the latest research on the digital skills crisis, focusing on the factors that contribute to digital exclusion. Through an extensive analysis of current literature on the digital divide, the authors discuss digital skills gaps, namely the exclusion of a sizeable part of the workforce from the digital market economy—and women in particular. Studies indicate that exclusion from the digital market is augmented and reinforced when combining the gender dimension with other exclusionary factors such as disability, age, race and socioeconomic background. Research confirms that the gender imbalance in ICT and related sectors persists today, despite decades of equal opportunity policies, legislation and government initiatives. Women are still underrepresented and digitally excluded and efforts to attract, recruit and retain girls and women in ICT and STEM seem to be failing, reinforcing the gender gaps: participation gap, pay gap, and leadership gap, a result of the deep-rooted *gender order* reflected in the latest Global Gender Gap Report and Index. A growing body of research of the twenty-first shows that inspiring girls and women into technology—increasing the talent pool in ICT and STEM— requires engendering technology, eliminating gender stereotypes, and raising the profile of female role models and mentors. Studies repeatedly argue that engendering technology entails women's agency and economic empowerment. Accordingly, the authors include recommendations from inspirational role models and mentors, three successful women in ICT, STEM and Information Society who have made a difference. All three, following a series of semi-structured interviews, propose engendering technology to increase the female talent

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pool in addition to engendering STEM education, that is to say, including the gender dimension.

Keywords: engendering technology, digital divide, digital exclusion, gender gaps, disability, age, skills gap, women entrepreneurs, leadership gap, digital inequality, gender devaluation

1. Introduction and Background: Engendering technology

Figure 1: Engendering technology-empowering women[i]
(Source: painting-collage by the artist Areti Kamperidis in Nancy Pascall's private collection)

> *"We are living in this digital bazaar where anything that is not built for the network age is going to crack under its pressure. Future jobs are likely to pair computer intelligence with the creative, social and emotional skills of human beings* (Elliott, 2017: 3).

In this study the authors examine the digital skills crisis, discussing the factors that contribute to the digital divide, such as gender, socio-economic status, race, disability, and age. An analysis of current research on the digital divide (44 scientific studies/articles, reports, dissertations), including the 2018 World Economic Forum Global Gender Gap Report, indicate that while technology is changing our world, diversity in tech is lacking. The exclusion of a sizeable part of the workforce from the digital market economy—and women in particular—suggests that we haven't *come a long way since* Mark Warschauer's (2003) study on *Technology and Social Inclusion:*

Rethinking the Digital Divide, or Saskia Everts' (1998) *Gender and Technology: Empowering women, Engendering development.* Despite efforts to attract more girls and women in the ICT and STEM sectors, the relevant statistics show that there has been no real improvement[ii] (World Economic Forum Insight Report, 2019; World Economic Forum, 2018; DESI, 2017; Cedefop, 2016).

Older studies indicated that efforts to engender technology (Kwolek-Folland 1994, Everts, 1998, World Bank, 2001) seem to have failed, especially if we take into account that only 22% of Artificial Intelligence (AI) professionals globally are female, compared with 78% who are male, according to the 2018 Global Gender Gap Report (World Economic Forum, 2018).

Since 1994 research has been focusing on increasing women's participation and economic empowerment by engendering technology, engendering development, engendering knowledge networks, engendering business, engendering management, engendering energy, engendering the workplace, engendering AI, and engendering leadership (Kwolek-Folland, 1994, Everts, 1998, World Bank, 2001, Tuana & Morgen, 2001, Batliwala & Reddy, 2003, Pattanaik, 2005, Pascall, 2012, Kamberidou & Fabry, 2012; Farrel, 2016, 2014; World Economic Forum, 2018; Duke, 2018; World Economic Forum Insight Report, 2019).

Engendering a specific social space (i.e. technology, politics, economy), a professional activity or a discipline (i.e. STEM, IT, entrepreneurship) means integrating the gender dimension into the equation so as to reduce women's underrepresentation and promote women's economic and social empowerment. Engendering technology denotes the integration of gender (gender awareness and sensitization) into technology, research and development, and concentrating on the economic empowerment of women. Engendering ICTs entails women's agency: dynamic involvement, dynamic participation, engagement, activism, and consequently women's economic empowerment. In other words, it means closing three major gender gaps: the participation gap, the pay gap and the leadership gap.

Nancy Pascall (2012) argues that engendering technology denotes more women in the design, production and use of technology. Her thesis advocates an "*engendered technology*" or "*the engendering of technology*" that entails the creation of new dynamic communities (to wit women's agency/female participation) shaped by the rapid development of technology producers, consumers, entrepreneurs, and of course, users. "*Engendering*", argues Pascall (2012), deals with employment and therefore the financial empowerment of women, along with additional issues that contribute to women's empowerment in a holistic manner, be it in their professional or private life, such as entertainment, information and consumer power. Pascall's (2012) *ICT Getting In, Staying In* model identifies four main career choice influencing factors—school, family, peers and environment/media—that she argues create hidden biases and reinforce existing gender stereotypes. Following an analysis of the model, she identifies areas for intervention, such as eliminating technophobia by training the trainers (beginning with kindergarten teachers); treating boys and girls in the family and school environment in the same way; using social media to raise awareness; fighting stereotypes, especially in

the media world; creating vocational training and flexible ICT employment conditions; allowing for a work-life balance, family oriented work environment to facilitate the care of children, and so forth.

With regard to the concept/term of engendering, Angel Kwolek-Folland's (1994) book titled *Engendering Business* challenges the notion that neutral market forces shaped American business, arguing instead for the central importance of gender in the rise of the modern corporation. "*Engendering development*", according to Saskia Everts (1998), meant the integration of gender into technological development through gender sensitization and gender analysis. The conference "*enGendering Rationalities*" held at the University of Oregon in April 1997 brought together feminist scholars from different fields and disciplines. The result was *Engendering Rationalities*, a book on women's empowerment, feminist epistemology, and cutting edge feminist investigations (Tuana & Morgen, 2001). At the international symposium on *Women and ICT: creating global transformation*, in Baltimore, Maryland, Dillip Pattanaik (2005) argued for "*engendering knowledge networks*" and as a result empowering women through ICT. Post feminists, like Sherry Turkle (2011) emphasize that "*the engendered construction of technology*" guarantees that we can do everything we want everywhere and with anyone, although it can also overwhelm and drain us, due to relentless connections that lead to a new solitude or void. Similarly, in her discussion on "*engendering development*", Everts (1998) examined how technological development could be both an ally and a threat to women with regard to their social roles. In exploring women's technology needs in theory and in practice, Everts (1998) provides a practical guide for the integration of gender into technology and development. She focuses on women's economic empowerment through technology, in addition to how technology itself can empower and disempower. Her book offers an overview of the technology and gender debate of the period, as well as "*a model-training program*" for successful technology transfer. She examines the benefits of existing market-driven technological promotion of the late twentieth-century and describes the programs for introducing technological innovations to women's projects along with the problems women confront—such as lack of access to funding-finance, training, and sustainability—which seem to resemble those faced by women today, in the twenty-first century.

James D. Wolfensohn, President of the World Bank in 2001, observes that "*Engendering Development provides policymakers, development specialists, and civil society members many valuable lessons and tools for integrating gender into development work*" (World Bank 2001: xii). In a report titled *Engendering Development Through Gender Equality in Rights, Resources, and Voice,* Wolfensohn points out that the report's evidence and analysis provides "*effective strategies to promote equality between women and men in development. In doing so, it helps us—as policymakers and as members of the development community—to realize our commitment to a world without poverty*" (World Bank, 2001: xii).

With regard to the developing world, although the concept of *engendering* is rarely used, the Martha Farrell Foundation (MFF) and Society for Participatory Research in Asia (PRIA) had organized a workshop on "*Engendering Leadership in Organisations"* on 10-11 March 2016. The report, following the conference, points out

that "*engendering organizations*" requires "*engendering leadership*". Moreover, India could improve its GDP growth by more than 2 per cent per annum if gender equality in the country increases (Farrel, 2016).

Srilatha Batliwala and Amulya Reddy (2003) discuss "engendering energy" for women's economic and social empowerment. The first challenge, they argue, arises from the gender disaggregation of energy consumption patterns in a case study, a village of Pura in South India. The results of their quantitative study on the rural consumption patterns show women work more hours than men, have a heavier workload than men, and eat last and the least in a family. The gender distribution of labor, along with other factors, result in more negative health impacts for women as compared to men. Thus, taking into account the technological opportunities that exist for energy interventions, Batliwala and Reddy (2003) propose a paradigm shift. They recommend empowering women through energy entrepreneurship, specifically promoting women as energy entrepreneurs or managers of enterprises. They argue that such an approach would "*engender energy*" by converting it into a force for improving their quality of life.

> *"I was a 'business girl', that's what I was, with those brief words seventy-year old Alice Peterson summarized her life in 1984. She had worked for 45 years as a clerk and a bookkeeper in a small bank […] Why would a seventy-year old woman refer to herself as a girl?"*

This is how Kwolek-Folland (1994) begins *Engendering Business*, emphasizing in her introduction the importance of integrating the gender dimension. Her study presents a detailed view of the gendered development of management and male-female job segmentation in the United States, beginning in the late nineteenth century. The fastest growing segment of women's labor in the late nineteenth century, she argues, was clerical work, and the most rapidly growing clerical industries were banking, trust, real estate, and insurance. The most pronounced changes in the gendered nature of the workforce were observed in the financial industries. She points out that middle class culture in the United States and in Western Europe, used gender terms and relationships drawn from biology to describe other non-biological (social) phenomena, such as economics, education, politics, social relations, morality, physical space, architectural space and status in the gendered workplace, office clothing, and office workers' leisure activities (Kwolek-Folland 1994).

In her book *Engendering the Workplace*, Martha Farrel (2014) focuses on promoting gender conductive workplaces through gender awareness. She addresses the need for gender sensitization in the workplace in order to eliminate gender discrimination and sexual harassment. She examines how sexual harassment is perceived by both women and men and discusses measures to be taken to create safe and secure work environments, such as capacity building on issues of gender sensitivity, networking with international organizations such as the International Labor Organization (ILO) and access to international conventions such as Convention on the Elimination of all Forms

of Discrimination Against Women (CEDAW). Two years later, Farrel (2016:2) argues that "*engendering organizations*" requires a new kind of leadership that provides the necessary policies and procedures that define an organization's culture.

So have we moved forward? Do we need to continue arguing for engendering the workplace, i.e. integrating the gender dimension? On a global level, the World Economic Forum's 2018 Global Gender Gap Report and Index found that while the global gender gap has narrowed slightly, fewer women are participating in the workforce, current trends indicating that the overall global gender gap could be closed in 108 years! (World Economic Forum, 2018).

The World Economic Forum (2018) suggests that the rise of new technologies across a range of industries may have been playing a role in intensifying gender gaps, especially in the fields of Artificial Intelligence (AI), as algorithms often reflect the implicit gender biases of their creators. LinkedIn data released in the World Economic Forum's Global Gender Gap Report shows that between the years 2015-2017, globally there was an increase of 190% in the number of workers with AI skills, the highest paid tech experts, although as cited earlier, only 22% of AI professionals globally are female. Consequently, if the gender skills gap continues it will also intensify gender pays gaps in the industry. Undeniably, LinkedIn's analysis found a significant gap between female and male representation among AI professionals and research shows no signs that this gap is closing (World Economic Forum Insight Report, 2019):

> "*Over the past four years, men and women have been adding AI skills to their profiles at a similar rate. This means that while women aren't falling further behind, they also aren't catching up. If the current trend continues, male AI professionals will continue to outnumber women, even as both genders continue to gain AI skills*", argues Sue Duke (2018), Senior Director, Public Policy, LinkedIn.

Why are women underrepresented in the cybercommunity? A plethora of studies have repeatedly examined the causes and the gender gaps: participation gap, pay gap, leadership gap, including the glass ceiling, work-life imbalance, and leaky pipeline (Kiritsis & Pantouli, 2016; Pascall, 2012; Kamberidou, Patsantaras, Pantouli, 2007; Kamberidou, 2010; 2011; World Bank in 2001; Everts, 1998; Kwolek-Folland, 1994). Statistical evidence and a broad literature review on the initial fact that women are underrepresented in the ICT sector can be summarized as follows. Underrepresentation begins at university level. Although women are a majority in tertiary education, few attend scientific courses and in particular engineering and computing. This is due to cultural and socialization processes: the way girls are brought up; the influence of parents and teachers; technophobia transmitted at school at an early age; gender stereotypes or stereotypical representations of women in technology; career and study 'choice' which is biased due to the four reasons stated previously. Additionally, studies identify this underrepresentation pattern in the Academia, in Research and in Employment and attribute it to: (1) misconceptions about job and job requirements, especially in terms of technical requirements and personal life, including work-life

balance, (2) career stagnation (lack of promotions and/or mobility), (3) difficult access to research and funding, (4) no progress or advancement in the academic hierarchy and/or leadership/management positions and (5) no recognition of technical qualification, i.e. women who are engineering and computer science graduates are usually have administrative or non-technical jobs (Kiritsis & Pantouli et al., 2016).

With regard to Europe, one need point out here that since 2004 the following initiatives were launched by the European Commission to overcome barriers, eliminate social stereotypes, and increase the number of women in information society, the ICT sector, and STEM: the regular Consultation Workshops on Women and Technology of the Gender Action Group (GEAG) of the European Commission DG for Information Society and Media; the European Centre for Women and Technology (ECWT); The Code of Best Practices for Women and ICT; IT Shadowing events for girls; Projects, programs, and conferences on (1) mentoring, (2) family interventions, (3) retraining of women returners; Digital Europe; "Women in the Information Society Seminar in Brussels; the Digital Agenda Assembly: Women for smart growth; the 1st European Celebration of Women in Computing (ECWC); the 1st European Commission Shadowing Conference "Move out of the shadow! Seize the opportunITy!"; Beyond the Glass Ceiling: Women Academics in Engineering, Technology and Life Sciences across Europe, and others. Indeed, statistical evidence and estimations indicate that some improvements can be seen, but the gender imbalance in ICT and related sectors persists today. Gender discrimination continues due to: 1) gender stereotyping and women's underrepresentation/gender participation gap, 2) women engineers and computer scientists are not taken seriously and most importantly 3) women are underrepresented in management-leadership positions/leadership gap. It should be noted that research indicates that the ICT sector is a key driver for growth and jobs, and as regard the EU economy almost 70 percent of ICT-related jobs are to be found outside the ICT sector (Kamberidou & Patsantaras, 2004, 2006; Pascall, 2012; World Economic Forum, 2018).

According to the World Economic Forum Insight Report (2019), Europe is lagging in the digital transformation of industries key to its success in the Fourth Industrial Revolution (4IR), and large platform companies from North America and Asia are beginning to dominate emerging deep technologies. Europe is behind in investment in new technologies such as AI, where it captured only 11% of global corporate investment and venture capital in 2016, compared to 50% in the United States and 39% in China. Europe's innovativeness has lagged behind other regions, and private investment in research and development (R&D) has fallen behind the United States' by 0.4% of GDP, about $90 billion, in 2015, while total R&D spending has been stagnating at around 2% of GDP (World Economic Forum Insight Report, 2019).

Additionally, within the transformations brought about by the Fourth Industrial Revolution (4IR), digital skills are becoming increasingly essential for employment and employability, as well as getting access to a range of services and products **(**Carayannis **&** Campbell, 2018, 2014; Carayannis & Sipp, 2006). However, the Digital Economy and Society Index (DESI, 2017) shows that 44% of Europeans do not have basic digital skills,

and people lacking digital skills risk social, economic and political exclusion, and/or active roles and opportunities in all sectors of the public and private sphere.

Data from the European Centre for the Development of Vocational Training (Cedefop, 2016) shows that more than 7 in 10 adult employees in the EU need at least some fundamental (basic or moderate) ICT skills training to be able to perform in the workplace, and one in three are at risk of digital exclusion! Moreover, around 28% of the European workforce (EU28) ranks their own level of fundamental digital skills quite low in relation to what is required, and *as if* that weren't enough, ICT users are more likely to be highly-educated men or male ICT industry employees (Cedefop, 2016:10). Moreover, a sizeable gender pay gap emerges in technology-rich environments, with men holding the well-paid jobs with good career prospects as ICT specialists (OECD, 2016; World Economic Forum, 2018).

1.1 Barriers to inclusion

Other than gender, namely being a female, research confirms that obstacles to obtaining digital skills are disability, socioeconomic background, race, age and poverty (OECD/ILO, 2017; Raja, 2016; World Bank, 2016; House of Commons 2016; Warschauer, 2003). According to the November 2017 joint OECD and ILO[iii] report, poverty is the major obstacle to obtaining digital skills, followed by social stratification, family structure, socialization, income and educational levels, as well as demographic elements (rural vs. urban areas), i.e. urban areas continue capturing the majority of the gains for economic growth (OECD/ILO, 2017).

Mark Warschauer (2003) had initially pointed out that less wealthy countries lose out and have less of a competitive advantage due to globalization and "*the unfortunate fact*" that the English language dominates web traffic. He presented case studies from developed and developing countries—the United States, China, Egypt, Brazil and India—examining the ways in which differing access to technology contributes to socio-economic inclusion and stratification. Warschauer (2003) also emphasized the benefits of social networking, using the Internet to increase social capital, necessary to achieve social inclusion. He described the digital divide as a complex, multi-layered digital inequality, arguing that in order to fill in the digital gaps and eliminate digital inequalities, what was necessary was effective integration of technology into societies, communities, and institutions along with appropriate content. At this point, the authors of this paper would like to observe that this is an egg-chicken situation as socio-economic exclusion and social stratification influence access to technology.

The World Bank (2016) report argues that bridging the disability divide through digital technologies could lead to overcoming major barriers to inclusion. It is important to note that around 15 percent of the world's population, specifically over a billion people; have disabilities, 80 percent of them living in developing countries and facing higher rates of multidimensional poverty as compared to persons without disabilities (Raja, 2016; World Bank, 2016). The combination of disability with gender reinforces potentials of exclusion from the digital market.

Statistical evidence from the UK shows that older people and the severely disabled are experiencing greater risk of becoming digitally excluded. Data from the Office for National Statistics (ONS) shows that 50% of all digitally excluded people in the UK have a disability, and only 51% of those with a disability are internet users, compared to 84% of the general population. According to the 2016 report of the House of Commons Science and Technology Committee, digital exclusion remains stubbornly high in the UK with an estimated 23% (12.6 million) of the adult population lacking basic digital skills: 49% are disabled, 60% have no formal education qualifications and 63% are over the age of 75. Additionally, an estimated 5.8 million (46%) have never used the internet at all. The digital skills gap is costing the UK economy an estimated £63 billion a year in lost additional GDP, and consumers who are not online are missing out on average savings of £560 a year. It is important to point out here that around 10% of the population may never be able to gain basic digital skills due to socioeconomic background and poor literacy skills, with the severely disabled and older individuals facing digital exclusion (House of Commons 2016).

The findings also show that: "*Black and minority ethnic groups are over-represented in the digital/IT sector, as are those with a disability, but under represented at senior levels. Socioeconomic background strongly affects whether an individual enters the scientific workforce*" (House of Commons 2016: 85-86).

The Lloyds Banking Group's Business Digital Index survey shows that 1.2 million small businesses in the UK lack basic digital skills, and despite government initiatives to rectify this, almost 50% of employers have a digital skills gap. The missing skills needed for the digital economy demonstrate that the UK's approach to developing digital skills is weak, indicating that the digital skills gap of children and young people is carried over into their working lives. Businesses report that they have struggled to fill at least one vacancy when trying to recruit analysts and despite the vacancies, some 13% of computer science students are still unemployed six months after graduating (House of Commons, 2016).

Undeniably, not only gender, but socio-economic status, disability, age and race remain variables of digital exclusion, as confirmed and reiterated in a plethora of studies since 1998, and specifically in research that investigates the digital divide, connectivity, access and use of ICTs, including the impact and use of the internet by socially disadvantaged groups (Everts, 1998; Warschauer 2003; Foley 2004; Kamberidou & Patsantaras 2004, 2006; Pascall 2012, 2008; Kamberidou, 2013; Ashcraft, McLain & Eger 2016, Deloitte 2016, Mims 2017).

2. Assessing Gender Gaps: Global Gender Gap Report 2018

Since 2006 the World Economic Forum's (WEF) Global Gender Gap Report has been tracking progress in closing gender gaps while examining the evolution of the overall Global Index (gender parity) by region.[ii] The Global Gender Gap Report 2018 presents

[ii] The 2018 Global Gender Gap Report spotlights the progress towards gender parity made over the past decade in East Asia and the Pacific; Eastern Europe and Central Asia; North America; Western Europe;

information and data compiled and/or collected by the WEF, using population-weighted group averages. It provides an annual estimate of the time required to close the gender divide, to wit the divide between women and men in Employment, Education, Health and Politics.

Specifically, the 2018 Global Gender Gap Report benchmarks 149 countries on their progress towards gender parity across four thematic dimensions: (1) Economic Participation and Opportunity, (2) Educational Attainment, (3) Health and Survival, and (4) Political Empowerment. For the first time, this edition includes digital skills and gender gaps related to Artificial Intelligence (AI). The 2018 Global Gender Gap Report shows that the overall global gender gap has been reduced by 0.03% since 2017 and 3.6% since 2006, current trends indicating, as previously cited, that the overall global gender gap can be closed in 108 years (World Economic Forum, 2018).

Progress towards gender parity, since 2006, is proceeding at different rates across the eight geographic areas examined in the 2018 Global Gender Gap Report: In Western Europe, current progress rates indicate that the overall global gender gap can be closed in 61 years. In South Asia in 70 years; in Latin America and the Caribbean in 74 years; in Eastern Europe and Central Asia in 124 years; in Sub-Saharan Africa in 135 years; in the Middle East and North Africa in 153 years; 171 years in East Asia and the Pacific in 171 years, and in North America in 165 years. The 2018 Global Gender Gap Index reflects the gender gaps in each geographic region, and specifically the variations in time required to close gender gaps across regions. The report also argues that these estimates towards achieving gender parity could change, given that policy-makers and other stakeholders can fast-forward processes through stronger actions or interventions.

The percentages that follow provide a snapshot of the current regional average gap closed so far: Western Europe (76%) with a gender gap of 24% and North America (73%) with a gender gap of 27%. In other words, Western Europe records a gender gap of 24%, placing it ahead of North America which has a gender gap of 27%. Additionally, in line with the report, Eastern Europe and Central Asia (71%), Latin America and the Caribbean (71%), East Asia and the East Asia and the Pacific (68%), Global Weighted Average (68%), Sub-Saharan Africa (66%), South Asia (66%), Middle East and North Africa (60%). Namely, in 2018, as shown in the percentages, at a global level four regions have a remaining gender gap of less than 30%—the same as last year's. Latin America and the Caribbean (29% gender gap), Eastern Europe and Central Asia (29% gender gap), and Western Europe, as previously cited, records a gender gap of 24%, placing it ahead of North America (27% gender gap). The Global Gender Gap Index 2018 by region also shows that the East Asia and Pacific region ranks ahead of Sub-Saharan Africa, with a remaining gender gap of 32% and 34% respectively, while South Asia, has a gender gap of 34% and ranks ahead of the Middle East and North Africa which have a 40% gender gap (World Economic Forum, 2018: 17-18).

South Asia; Sub-Saharan Africa; Middle East and North Africa; and Latin America and the Caribbean. Six of the seven regional average scores improved compared to 2017, and two registered a slight reversal. The most improved in 2018 is Latin America and the Caribbean, with a progress of almost 0.6% (World Economic Forum, 2018: 16-17).

As depicted in the 2018 Global Gender Gap Index, performances vary significantly within regions as well. For example, despite Western Europe's relatively high regional average, there is a wide spread of outcomes among the region's 20 countries, such as varying performances in the subindexes: (1) Educational Attainment, (2) Economic Participation and Opportunity (3) Political Empowerment, and (4) Health and Survival. With regard to the global top 10 list, the Global Gender Gap Index shows that the top spots continue to be held by smaller Western European countries, the Nordics occupying the top four positions. Western Europe—with an average overall gender gap of 24.2% is home to four of the top 10 countries in the Index with regard to global rankings for 2018: Iceland (1st rank/position), Norway (2nd), Sweden (3d), Finland (4th) Nicaragua (5th), Ruanda (6th), New Zealand (7th), the Philippines (8th), Ireland (9th) and Namibia (10th). The top 10 list includes two countries from the East Asia and the Pacific region, one long-established and one new entrant from the Sub-Saharan Africa region, and one country from the Latin America and the Caribbean region. The three countries at the bottom ranks of the region are Greece (78th), Malta (91st) and Cyprus (92nd), with a remaining gender gap of more than 30% (World Economic Forum, 2018: 18, 27, 11).

Consistent with North American rankings by region, the Global Gender Gap Index shows that Canada holds the 16th rank and the United States the 51st. Canada (16th) maintains its position in the global top 20, and the same rank as that of the previous year on the overall Index. Additionally, fully closed since 2013 is Canada's gender gap on the Educational Attainment subindex, although its Health and Survival gender gap remains. It is important to point out here that Canada has closed over 77% of its overall gender gap, an increase of 3% since 2015.

The United States (51st position/rank) has moved down two spots compared to 2017. Modest improvements have been recorded in the Economic Opportunity and Participation subindex—mainly with regard to the gender pay gap, recorded in the report as the "wage equality for similar work"—but virtually no change has been observed in the Political Empowerment subindex, which remains at its lowest level since 2007, with a significant decrease in gender parity in ministerial level positions. With regard to the Economic Opportunity and Participation subindex, the United States continues to rank in the Global Index top 20, highlighting the extensive potential of the country's next-generation female workforce. The United States has closed 72% of its overall gender gap, a decrease of 2% since 2015 (World Economic Forum, 2018: 25).

According to the report, the gender gap differences between the highest-ranked and lowest-ranked countries in the region is about 3.4% for Educational Attainment and just over 1% for Health and Survival, with seven of the 20 countries fully closing their gender gaps on education indicators. The report also underlines that no country in the region has managed to fully close its Health and Survival gender gap, as was the case in the previous year. With regard to the Economic Participation and Opportunity subindex and the Political Empowerment subindex, gender parity levels in countries across Western Europe are uneven: respectively, 20% and over 50% differences in gender gap size between the region's best and worst performers. The report also

indicates that eleven of the region's 20 countries have achieved a gender parity level of at least 70% on Economic Participation and Opportunity, including two countries— Sweden and Norway—that have crossed the 80% mark. The 2018 Global Gender Gap Index also shows that four countries have reached a gender parity level of over 50% on Political Empowerment and eight countries have closed between 30% and 50% of their gender gaps, although eight countries have yet to close at least 30% of their gender gaps on this subindex (World Economic Forum, 2018: 27).

Out of the 20 countries from the region covered by the Index, 14 have increased their overall scores compared to the previous year, while six have recorded lower scores. Due to their sustained progress on the Political Empowerment subindex and continued strong performance on the Economic Participation and Opportunity subindex, four countries— Iceland (1st), Norway (2nd), Sweden (3d) and Finland (4th)— defend their top-ranked positions in the Index. On the other hand, the Index's estimated earned income scale reveals that in the Nordic countries, additional efforts will continue to be needed to fully close the gender gap in income and to achieve full wage equality. Ireland (9th) likewise maintains its global top 10 position, with a marked improvement in closing the gender gap in estimated earned income. Although France (12th rank) remains in the bottom half of the Economic Participation, some improvements are recorded in 2018, predominantly with regard to Political Empowerment. This is due to the increased gender parity in the country's composition of parliamentarians and a narrower gender gap in women's estimated earned income (World Economic Forum, 2018: 18).

2.1. Assessing Gender Gaps in Artificial Intelligence (AI)

For the first time the 2018 Global Gender Gap Report examines the growing impact of AI— a prominent driver of change within the transformations brought about by the 4IR— and provides a list of the top 20 countries ranked according to their AI talent pool concentration. In assessing gender gaps in AI, in partnership with the LinkedIn Economic Graph Team, the World Economic Forum (2018) spotlights the increasing expansion of AI which is creating the demand for a range of new skills, among them neural networks, deep learning, machine learning, and 'tools' such as Scikit-Learn and Weka.

To understand the prospects for gender parity among industries, the Global Gender Gap Report analyses female representation within this new talent pool and finds a significant gender gap among AI professionals. It is important to reiterate here that only 22% of AI professionals globally are women, compared to 78% who are men. This accounts for a gender gap of 72% yet to close. AI talent is most prominent in the United States (with 23% female AI talent), closely followed by India and Germany. However, Germany has the largest AI gender gap (16% female AI talent). The smallest gender gaps are recorded in Italy, Singapore and South Africa, where on average 28% of the AI talent pool is female, in contrast to 72% male. As highlighted in the report, the gender gap has remained constant over the past four years while the rate at which women and men have acquired AI skills has progressed in tandem. Moreover,

according to the report, the gender gap has remained constant over the past four years even as the overall number of professionals with AI skills has risen, seeing the share of female AI talent waver between 21% and 23%, a four-year trend that shows the need for a more focused intervention (World Economic Forum 2018).

Over half of all professionals who possess some level of AI skills are employed across two industries (1) Education (inclusive of Higher Education) and (2) Software and IT Services, which account for 19% and 40%, respectively, of the AI talent pool. Women employed in the Education sector comprise 4.6% of that talent pool, or just under one-third of the male AI talent pool in this sector. Women in the Software and IT Services Industry make up 7.4% of the AI talent pool—or just one-quarter of the male AI talent pool. The Non-Profits, Health Care and Education industries have the smallest AI talent gender gaps. On the other hand, the overall AI talent pool within Healthcare industries and Non-Profits remains limited, with those industries making up 2/% and 4% of the AI talent pool, respectively. Additionally, AI talent gender gaps are imperfectly correlated with the overall gender gaps in industries. The largest industry gender gaps can be found in Software and IT Services, Energy and Mining, and Manufacturing, which have closed 42%, 34% and 33% of their gender gaps, respectively. Conversely, in the Education, Non-Profits and Health Care industries the share of women is greater than that of men. However, the gaps within the AI talent pool are often three times larger, and women are consistently outnumbered by their male counterparts irrespective of industry (World Economic Forum 2018: 30-31).

Moreover, the Global Gender Gap Report provides detailed data on 1) the gender gap within the AI talent pool, by industry, across all professionals; 2) figures on the share of female and male AI talent pool, by AI skills; 3) and data on the share of LinkedIn members with AI skills, by occupation and gender. A range of skills that were more prominent among the female AI talent pool (at LinkedIn for example) are skills in natural language processing and data structures, and information retrieval skills, whereas emerging skills such as deep learning, neural networks and computer vision are more commonly found among male AI professionals. Women with AI skills are more likely than men to be employed in research, information management and teaching positions or as data analysts (i.e. 4.2% of women employed as data analysts in contrast to 3.0% of men in AI talent pool). Male AI professionals, as emphasized in the report, are usually in senior levels or executive roles, such as head of engineering, head of IT, software engineer, business owner and chief executive officer.

3. Gender stereotypes: *Need to get them while their young*

Engendering technology—intervening dynamically to integrate the gender dimension—is vital, since digital exclusion is rising and the digital skills crisis is being experienced in schools, higher education and workplaces globally. In the United States only 18% of computer-science degrees are granted to women. Even more alarming is that the proportion of women earning degrees in computer science has been declining since 1984 when it was 37% (Ashcraft, McLain & Eger, 2016). America's computing

workforce is 24% women and that proportion is also falling, despite the hundreds of millions of dollars the industry has spent on diversity policies and inclusion efforts, confirming Christopher Mims (2017) observation that "sexism in the tech industry is as old as the tech industry itself", as is racial-ethnic discrimination.

Ethnic diversity in computing also needs reinforcing, especially for women of color. In 2016, women in the United States made up 26% of the computing workforce, and less than 10% were women of color: 5% were Asian, 3% African American and 2% Hispanic, according to fact sheet of the National Center for Women & Information Technology.[iv] The fact sheet also shows that in 2015 only 18% of Information and Computer Science bachelor's degree recipients were women, and if this continues at the same rate, by the year 2024, of the expected 1.1. million computing–related job openings, only 45% will be filled by US computing bachelor's degree recipients (Ashcraft, McLain & Eger, 2016).

The gender participation gap (and leadership gap) also applies to the United Kingdome (UK), which holds the 15th position/ranking in the Global Gender Gap Index. Analytically, with regard to the distribution of performances across G20 countries, the nation with the highest progress towards gender parity is France (12), as cited earlier, "*followed by Germany (14), the United Kingdom (15), Canada (16), South Africa (19) and Argentina (36). Saudi Arabia (141), Turkey (130) and Korea, Rep. (115) make up the lower ranks of the group*" (World Economic Forum, 2018: 28).

According to the House of Commons Science and Technology Committee report, women make up only 17% of IT professionals in the UK and are less likely to be employed in graduate level science professions like mathematics, computer sciences, engineering and technology, as compared to men. They are highly underrepresented in senior/leadership roles, although they are not underrepresented in the overall scientific workforce (House of Commons, 2016).

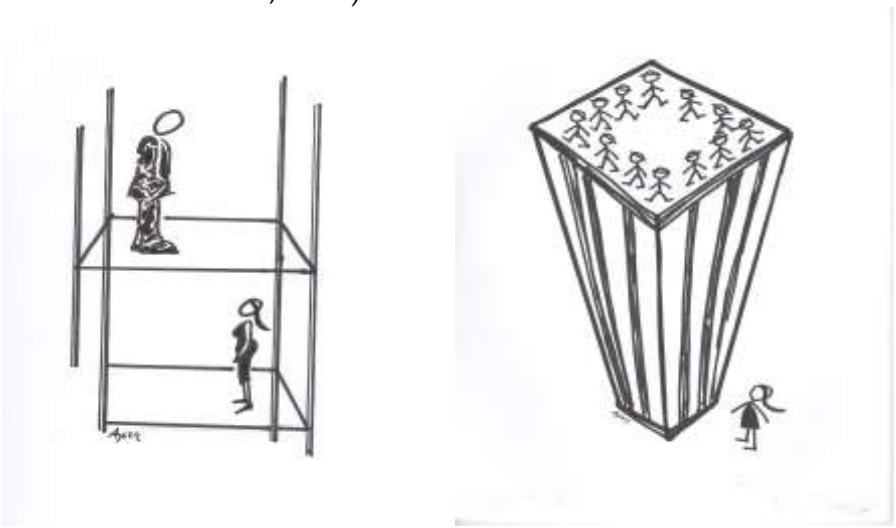

Figure 2: The *gender divide—glass ceiling and leadership gap*
(Source: sketches by the artist Areti Kamperidis)

In Wales, the figures show that the proportion of women working in key sectors like ICT, construction and life sciences is in fact lower than it was in 2007—and only

25% of people in ICT are women (Dickins, 2017). The Skills and Science Minister, Julie James, said the underrepresentation of women in the STEM workforce was a "*critical issue for Wales*" and encouraging more women and girls to pursue STEM opportunities and careers made "economic sense" (Dickins, 2017), or as the authors of this paper argue, integrating the gender perspective means eliminating the waste of female talent—using all human resources available —and as a result having a vital competitive advantage and boosting innovation, a prerequisite for economic growth and effective sustainable development.

This means engendering STEM and ICT, and primarily *getting them while their young*, in primary school or kindergarten, since gender stereotypes and social biases start at an early age. Decades of research has been stressing the need to reshape STEM education to include the gender dimension: promote school collaborations with employers, industry and firms to engage in initiatives that attract more girls: i.e. shadowing events, mentors, role models, science projects (Carayannis & Stewart, 2013; Kamberidou & Fabry, 2013; Kamberidou, Patsantaras & Pantouli, 2007).

The prevalence of gender stereotypes in the UK and consequently the importance of *getting them while their young* is clearly reflected in the Deloitte report, "Women in STEM Technology, career pathways and the gender pay gap" (Deloitte, 2016). The report examines future changes in the job market and establishes the connection between academic choices made by girls and boys (from a young age and through university life) and the choice of jobs and career pathways that they are eventually likely to follow. This is done through an analysis of more than five million 2016 GCSE[v] entries and provisional results by the Joint Council for Qualifications, which showed noteworthy differences in the subjects chosen by boys and girls.

Significantly more boys than girls entered subjects including Technology, Construction, Engineering, Computing, Manufacturing and Economics. Girls were more likely to study Health and Social Care, Home Economics, Performing Arts, Social Science subjects, Art and Design, and Drama. Additionally, the data for girls and boys taking their GCSEs in 2016 showed that girls perform considerably better than boys at GCSE in nearly all subjects, including most STEM subjects, such as ICT, Computing, Science, Chemistry, Biology and Physics. According to the report, for the first time, boys marginally outperformed girls in Mathematics. The gender differences in subject choices were evident at A-Level: boys remaining much more likely to pursue STEM subjects, although their performance was not as strong as that of the girls. In terms of absolute numbers, Mathematics was the most popular subject for boys and English for girls (Deloitte, 2016).

According to the House of Commons Science and Technology Committee report, despite extensive and long term campaigns from industry and government in the UK, there is a gender imbalance in those studying computing: 16% of computer science students are female, a low level of representation which continues through higher education and in the workplace. The House of Commons (2016) report indicates that the gender imbalance needs to be addressed by embedding science and digital skills in the wider school curriculum as part of the solution. Furthermore, the deep-rooted *gender*

order is clearly observed in the results of a survey with over 4,000 young women, girls, teachers, and parents in the UK and Ireland showing that 60% of 12-year-old girls "*thought that STEM subjects were too difficult to learn and nearly half thought that they were a better match for boys*" (House of Commons 2016: 157). Additionally, girls ranked their teachers and parents as their biggest influencers when making a decision about study choices, however, 51% of parents felt that they were ill-informed about the benefits of STEM subjects.

Gender stereotypes prevail in Greece as well. In a study on adolescent attitudes and behaviors, Dimitris Kiritsis and Olga Pantouli (2016) discuss influential factors in career pathways while focusing on the gender dimension. Questionnaires regarding career goals, future family roles, and the influence of gender were distributed to 229 teenagers (131 girls and 98 boys) 16-18 years old. Alarming were the results of the statistical analysis, the findings showing that 80% of the boys believe women should be the ones to be the primary housekeepers (in charge of housework) while 53% of the boys consider it much easier for a man to have a successful career, since women are primary housekeepers, and also confront gender discrimination which prevent them from having a successful career. Another cause for concern is the data showing that 40% of the boys (but only 9% of the girls) believe it is primarily the man's responsibility to be the *breadwinner*: financially support his family. The responses to the question on who should resign or leave his/her job if and when needed to take care of the children were also alarming: 94% of the respondents (boys and girls) agreeing it is the woman's responsibility to do so. Moreover, the data indicates that girls prefer the teaching profession, or choose fields that offer no job security or professional advancement, a finding interpreted as lack of information concerning future career choices and prospects, and/or adherence to traditional professions and role models, the goal being the work-life balance.

Gender stereotypes regarding technology are also observed in the attitudes of university students, and specifically at the Aristotle University of Thessaloniki, Greece (those enrolled in the Social and Theoretical Studies Departments). In this study, Pantouli (2008) examines the views and opinions of 40 female students, using the focus group method with 5 groups of 8 female students. She perceives and discusses their lack or limited computer use as compared to that of male students. The female students argue they will use computers in the future, when and if the need arises in their professional lives. They also associate or describe the computer use/engagement of their male friends and students as *male inclination for machines and technology*. Additionally, the female students perceive or describe themselves as socially *trapped* due to their *female nature*, taking on *the woman uninvolved in technology identity*. They identify themselves as *guests* in cyberspace, since they claim that they do occasionally and selectively use computers when they need to acquire data or information. How do they excuse their lack of agency? They exonerate themselves from any guilt by arguing that social roles in Greek society are gender-differentiated and gender specific.

With regard to the academia, Pantouli, Zarifis and Oliveira (2014) discuss *invisible* gender barriers (i.e. glass ceiling, leaky pipeline). Specifically, the study

discusses women's underrepresentation and social exclusion in Portugal and Greece—two countries with a high percentage of employed women scientists and researchers (44% and 36% respectively), higher than the EU-27 average (30%) at the time.[vi]

The comparative study of Portugal and Greece shows that despite the high percentage of women in science and research, women's underrepresentation in the workforce and especially in leadership positions continues and is a result of gender stereotyping/inequalities: the work-life imbalance; lack of time since women take primary responsibility of the family (housework, children, caregivers, care of the elderly/parents, in-laws); attitudes not related to scientific capability or excellence; perceptions of science as a male domain, an androcentric scientific community; the leadership-advancement gap in the scientific hierarchy; pressures and competitiveness of male colleagues regarding funding, research and development. Pantouli, Zarifis and Oliveira (2014), also point out that, as is the case internationally, women are underrepresented in the academic/leadership hierarchy in both countries. In Portugal, for example, although women's enrollment in Higher Education is close to 47% at Polytechnics (Universities of Technology), with a student rate of 39% in all universities, they are underrepresented in the academic/leadership hierarchy. Moreover, in the field of Engineering, an overwhelming percentage (77%) of men holds the position of professor.

Such results indicate that we need to rethink and redefine the model for professional life, especially in view of the fact that "*gender devaluation*" (Kamberidou 2011), i.e. the subtle processes by which women's contributions are minimized, undervalued or devalued in male-dominated professions, continues today. This gender devaluation is reflected in the narratives of 10 Greek women in STEM, who in order to overcome their professional marginalization/devaluation, adopted what they describe as male strategies and tactics.

Olga Pantouli (2015) interviewed 10 successful Greek women in STEM and discussed gender relations in the workplace: how they managed to navigate/pursue their careers, and how they succeeded or excelled in their scientific fields or disciplines. She does not focus on the repeatedly studied numerical comparisons between men's and women's participation, namely the gender participation or leadership gap. Instead her research highlights women's perceptions, insights, and emotions about their professional marginalization in the workplace: feelings of isolation, solitude, seclusion, alienation and barriers confronted. Their life stories/narratives leave no doubt that women's lonely and isolated career paths undermined or delayed their professional development, recognition and advancement.

In their narratives they claim to have adopted elements of the male culture— the androcentric academic and scientific community—imitating the successful strategies of their male colleagues. In so doing—and not disturbing the established *gender order* of academic and scientific institutions—they were accepted, recognized and acknowledged, facilitating their advancement. The accounts reveal that they had to center on struggling to establish themselves in their fields; over-come invisible gender barriers (glass ceiling, leaky pipeline) while hiding their personal difficulties and needs.

Consequently, they were unable to demand the changes most women pursue in the workplace (Pantouli, 2015), i.e. a family-friendly work environment, flexi-hours, work-life balance, breaking the glass ceiling (leadership gap), equal pay for equal work with men (pay gap), lack of which has been increasing the leaky-pipeline phenomenon

In other words, the leaky-pipeline (women abandoning their careers) is a result of the work-life conflict and the gender devaluation of women's work and contributions (pay gap, leadership gap). For example, women employed in the tech industry have been leaving at overwhelming rates (Ashcraft, McLain & Eger, 2016), an exodus attributed to "*gender fatigue*" (Kamberidou, 2011, 2010). In the UK pay parity between men and women is not forecast to be achieved until 2069, according to the Deloitte (2016), and a significant gender pay gap is also observed in the starting salaries between men and women who have studied STEM subjects (Deloitte, 2016; World Economic Forum, 2018).

4. Results and discussion: Digital skills, the great equalizer, a critical route out of inequality

Digitalization—liberating for those with skills and knowledge—has radically altered the nature of our lives, and those who are not sufficiently prepared for it, are condemned to a life without future prospects and work insecurity, among other things. Researchers have been repeatedly arguing that factors contributing to digital exclusion or the *digital divide*—a new form of social inequality regarding access to and use of information and communication technologies (ICTs)— include social stratification, employment status, the presence of children in the household, the relationship between household income and internet access, connectivity, technophobia, lack of assistance and support in using the internet and ICTs, particularly for the elderly, who complain and are bewildered by the array of online information, internet training and ICT skills development courses (Warschauer, 2003; Foley, 2004; Kamberidou & Patsantaras, 2004; Carayannis & Sipp, 2006; Pascall, 2008, 2012; Kamberidou & Labovas, 2012; Carayannis & Campbell, 2014, 2018).

The European Skills and Jobs Survey (ESJ) of the European Centre for the Development of Vocational Training (Cedefop, 2016) shows that more than 7 in 10 adult employees in the EU need at least some fundamental (basic or moderate) digital/ ICT skills to be able to perform their jobs. Around one in three of these employees however, are at risk of confronting digital skill gaps, and almost half of all employees in low-skilled occupations do not need ICT skills to do their work, since an amazingly high portion of the EU adult workforce is still employed in a semi-analogue world.

With regard to this great divide in the EU workforce, the ESJ focuses on three ICT levels— basic, moderate, advanced)—which are required to fill in or overcome the three digital skills gaps: 1) basic ICT level (ability to use a PC, tablet or mobile device for emailing or internet browsing), 2) moderate ICT (word-processing or creating documents and/or spreadsheets) and 3) advanced ICT skills: developing software, applications or programming; using computer syntax or statistical analysis packages.

Concentrating on ICT skills, the ESJ shows the exclusion of a sizeable part of the workforce from the digital economy and includes information on the (digital) skill mismatches of adult EU employees. Respondents were requested to assess their own level of digital skills (basic, moderate, advanced) and asked to report if they lag behind or exceed the skills needed in their work.[vii] According to the results of the study concerning the EU28 Member States, on average, around 28% of the European workforce ranks their own level of fundamental digital skills quite low in relation to what is required. In other words, they reported a digital skills gap with regard to their job needs— either a basic/moderate ICT level or advanced, and around 22% assessed that they require advanced digital skills (Cedefop, 2016).

The findings also show a 40% fundamental (basic and moderate) digital skill gaps (Estonia, Bulgaria and Portugal), as opposed to one in five in the Southern European countries (Greece, Cyprus, Italy). Workers in Sweden, Estonia, Portugal and Denmark are also the most susceptible to such skill gaps in advanced ICT skills. The Cedefop European skills and jobs survey also shows that over one third of those employed in the agricultural, accommodation, catering and food sectors show fundamental digital skill gaps. For example, the majority of the EU employees (52%) stated that a moderate ICT level is required to carry out their jobs; 19% require a basic level; around 14% indicated they required an advanced ICT level as opposed to 14% who stated they need no ICT skills at all in their jobs. Sweden, Denmark and Ireland are the EU countries in which more than 80% of their adult workforces needs at least a fundamental level (basic or moderate) of ICT skills to do their jobs, in contrast to Greece, Cyprus, and Romania where the same holds for about six in 10 workers. Portugal, Bulgaria, Latvia and the Netherlands have the highest share of employees (over a fifth) reporting that their jobs do not require any ICT skills at all. Together, more than seven in 10 (71%) EU employees need some fundamental level (basic or moderate) of digital skills to perform their jobs (Cedefop, 2016).

Another study directed toward improving skills use in the workplace, provides a comparative analysis on "*skills utilization approaches*" in the workplace across eight countries (OECD/ILO 2017). According to the latest joint OECD report, skills utilization approaches and strategies represent a new way of thinking about public policies. The report on *Better Use of Skills in the Workplace* argues that "*putting skills to better use can improve outcomes for individuals, employers and economies*", adding that skills represent the great equalizer, and provide a critical route out of poverty and inequality for many individuals (OECD/ILO 2017: 23).

Certainly, digitilization is driving amazing changes in skills demand. Workers across the OECD[viii] claim that their skills are not fully used in the workplace, despite potential benefits that a better use of talent and skills in the workplace could offer, for instance a more productive and innovative workforce, maximization of business performance and profitability. This skills gap represents a drag on local economic development placing downward pressure on job quality as well as reducing or limiting opportunities for economic diversification. Many countries across the OECD are dealing with stagnant productivity growth while inequalities related to employment and social

measures (benefits, privileges, care etc.) are simultaneously rising. Nevertheless, policies for better skills utilization— that could create the conditions for enterprise growth and new economic opportunity and development— still remain under-developed in many countries. Through case studies of eight OECD and non-OECD countries, this joint publication from the OECD and the ILO, not only explores program examples which aim to promote a higher level of skills use in the workplace, but focuses on the need to ensure that the issue of skills utilization is built into policy development thinking and implementation.[ix] Of course one could point out here that this has been repeatedly proposed in many studies. Nevertheless, the new OECD report (chapter 1), highlights a number of areas, where policies can be targeted for better results, especially regarding skills utilization which concerns the effective application of skills in the workplace to maximize employer and individual performance: "*As such it involves a mix of policies including work organisation, job design, technology adaptation, innovation, employee-employer relations, human resource development practices and business product market strategies*" (OECD/ILO, 2017: 3).

It is often at the local level, as the report emphasizes, where the interface of these factors can best be addressed, and specifically through policies which aim to improve skills use in the workplace, by addressing the multi-faceted challenges confronted by many local economies. This would contribute to national productivity and inclusive growth objectives. As previously cited, skills represent the great equalizer, providing a critical route out of poverty and inequality, and skills utilization approaches represent a new way of thinking about public policies, namely moving away from traditional supply side approaches to focus on how to better work with employers to raise the quality of jobs at the local level and provide employees with more autonomy to create innovation in the workplace.

4.1. Europe's digital performance: Basic, medium, advanced skills

The Digital Economy and Society Index (DESI)[x] provides significant indicators on Europe's digital performance while tracking the evolution of EU member states in digital competitiveness. DESI shows that in the EU, in 2017, Denmark, Finland, Sweden and the Netherlands have the most advanced digital economies, followed by Luxembourg, Belgium, the UK and Ireland. Romania, Bulgaria, Greece and Italy have the lowest scores on the DESI. In 2016 all Member States improved on the DESI, while Slovakia and Slovenia progressed the most: over 0.04 as opposed to the 0.028 EU average (DESI, 2017).

As regards the Human Capital dimension and digital skills, DESI measures the level of skills required in order to benefit from the possibilities offered by digital society. Such skills cover the whole spectrum from basic to advanced: *basic* user skills enable interactions online and consume digital goods and services; *medium* skills that enable the user to use professional tools, providing a workforce able to efficiently use technology for enhanced productivity and finally *advanced* skills that empower the workforce to use technology for enhanced productivity and economic growth, which include designing and producing the necessary technology (DESI, 2017).

However, Europeans still do not have *basic* digital skills, as Stuart W. Elliot (2017) points out in his extensive study on computers and the future of skill demand. Although 79% of Europeans go online regularly (at least once per week), up by 3 percentage points compared with 2016, 44% of Europeans still do not have basic digital skills.

Elliott's (2017) OECD report provides first-of-its-kind evidence-based insights into current computer capabilities with respect to certain human skills. To understand recent changes in skill demand, he examines workers daily computer capabilities, computer use, literacy level of proficiency, and general cognitive skills, using the OECD's Survey of Adult Skills, derived from the Program for the International Assessment of Adult Competencies (PIAAC). In his assessment of the computer capabilities that drive skill demand further in the near future, the findings are alarming: two-thirds of workers in OECD countries are using the literacy, numeracy and digital problem-solving skills with a proficiency at a level on a par with that of computers. Only 13% of workers use these skills on a daily basis with higher proficiency than computers.

PIACC is a program used to survey and measure key cognitive and workplace skills (proficiency in information, processing skills, literacy, numeracy and problem solving), and gathers data on how adults use their skills at work, in the wider community and at home. In the first chapter Elliott (2017) discusses the challenge computers pose to the future of work and education, setting out the context for carrying out an exploratory project on the challenge that computer capabilities will pose for work and education in the future. He presents an overview of existing research on past and future trends in skill demand along with examples with additional perspectives from economics, education and computer science. The second chapter provides an overview of the changes in worker skills and *skills utilization* over time, based on findings from PIAAC. One need point out here that since PIAAC has been carried out only once, the results are compared with those from an earlier study, that of the International Adult Literacy Survey (IALS). This comparison reveals that the proportion of the workforce with high literacy proficiency has decreased. So, to prepare students for the possible future and help policymakers understand how the education system needs to be shaped, he argues that we need to know which computer capabilities are now available and how they relate to human skills. This would help our understanding regarding which work tasks can potentially be automated in the near future, and "*this understanding can provide the basis for constructing realistic scenarios about the ways that jobs and skill demand will be redefined in the next few decades*" (Elliot 2017: 18).

PIAAC is perceived as a tool for understanding the implications of growing computer capabilities. It measures general cognitive skills: literacy, numeracy, and problem solving with computers, skills that receive extensive development during compulsory education. PIAAC measures these skills, due to their acknowledged importance, as outputs of the education system and as inputs in the workplace. Accordingly, Elliott (2017) discusses the changes in the use of these skills over the past decades and explores the implications of computers for further changes in the future.

He points out that a comparison of the PIAAC results with those of a similar international test in the 1990s reveals that workers of different levels of proficiency are more likely to use their literacy skills at work than was the case two decades ago.

On the other hand, regardless of this increased frequency of use, there is now a smaller proportion of the workforce with a high proficiency in digital literacy than in the 1990s in most OECD countries. Consequently, the increased use of literacy skills reflects an increased use by workers who have low or moderate levels of proficiency. The findings indicate that only 13% of workers in OECD countries now use the PIAAC skills on a daily basis with higher proficiency than computers; 25% of workers do not use the PIAAC skills on a daily basis at work; and 62% of workers use the PIAAC skills on a daily basis at work but with proficiency at a level that computers are close to reproducing (Elliott 2017).

In his interpretation of the results, Elliot (2017) emphasizes that different mixes of skills are needed for different work tasks: for some tasks the PIAAC skills will be of primary importance, for others they will be peripheral, and for some a combination of the latter will be needed with skills, such as vision, common sense, expert reasoning, physical movement and social interaction, in addition to a comprehensive program to assess these skills and understand how computers will affect employment.

"*Future jobs are likely to pair computer intelligence with the creative, social and emotional skills of human beings*", argues Elliot (2017: 3). To thrive in the digital economy, ICT skills will not be enough, according to the OECD policy brief on the future of work which emphasizes that "*re-skill and up skills*" (OECD, 2016: 3) will be required, specifically training and retraining, along with well designed second-chance programs to allow workers, employees and individuals to keep their skills up to date. It is also critical to increase diversity in STEM education and incorporate the human factor, defined by many researchers as soft skills, otherwise being creative, culturally sensitive, innovative, collaborative, and entrepreneurial, namely what Elliot (2017) described as a "different mixes of skills".

4.2. Demystifying and engendering the ICT sector

"*Digital skills today are as vital as electricity so go and get them*! (Elizabeth Pollitzer)

Embedding science and digital skills in the wider curriculum is only part of the solution. Complementary-human skills will be needed, ranging from good literacy and numeracy, to soft skills: social skills, flexibility, working collaboratively, transitional leadership styles, communication and teamwork skills, along with creativity, emotional intelligence and problem-solving skills (OECD, 2016; Kamberidou, 2013), in addition to engendering technology, increasing the talent pool to eliminate today's digital gaps.

Studies indicate that women enjoy a slight edge over their male counterparts when it comes to soft skills, which are actually interpersonal (people) skills. Researchers argue that women excel in communication skills, sharing information, drawing people into conversation and reproducing a culture of collaboration. They are consensus

builders, conciliators, peacemakers and better listeners than men (Woolley & Malone 2011; Kamberidou & Labovas, 2012, Kamberidou, 2013). The top self-described traits of the "*social woman*" (SheSpeaks Inc., 2011) is that she *listens* and *shares*, according to the results of an online survey with 3,963 women in the USA, conducted 13 to 15 September 2011. The survey shows that the *social woman* wants to share and listen and not just use the internet or social media as a megaphone to get her voice heard. In today's digital economy such soft skills (listening, sharing, and team building), whether the result of socialization, social conditioning or biology are a requirement. This does not mean that women are inherently more talented and better skilled than men. It does, however, indicate that gender diversity is essential to achieve better results, or as Woolley and Malone (2011) argue in their study, the collective intelligence of a group rises when the group includes women.

Addressing these issues, three inspirational role models and *agents of change*—Olga Stavropoulou (Greece), Elizabeth Pollitzer (UK), and Rosalie Zobel (USA, UK)—offer their invaluable advice. All three propose engendering technology—incorporating the gender dimension—to increase the female talent pool in addition to increasing diversity in STEM education, following a series of semi-structured interviews that allowed more flexibility, freedom to discuss more openly, and gain a better understanding. A brief sample of their recommendations follow:

> "*Establish soft skills empowerment platforms. Choose to be digital adaptable and digital resourceful! The Internet is the resource, your decision is to be digital resourceful. Either you choose fear or digital opportunity. That's Your Digecision! […] Via grassroots communities, we use soft skills as the password to women's digital inclusion. As such, we look into transforming a digital mind-set based on soft skills empowerment platforms that minimize digital fear and resistance through actual data, daily practices and hands on experience, rather than beliefs that hold women back from digital evolution and inclusion."Advises Olga Stavropoulou, President of Militos Emerging Technologies & Services, and social entrepreneur, who additionally emphasized the need to bridge the disability divide: "Bridging the disability divide through digital technologies or AI could lead to overcoming major barriers to inclusion.*"

Olga is the Coordinator of the Hellenic Unit of the European Network of Mentors for Women Entrepreneurs (Business Mentors) under the auspices of the European Commission, Directorate-General for Enterprise and Industry. She is also the Lead Coordinator of the 'Mellon W'network that up-skills unemployed women through the Mellon Skills Accelerator of Knowl Social Enterprise. Olga was appointed the Greek Ambassador of Global Women's Entrepreneurship Day, an initiative of WED NY Worldwide Movement, in partnership with U.S. State Department launched on Nov. 19, 2014 at the United Nations.

> "*Digital skills today are as vital as electricity so go and get them! Rethink how ICTs are presented to girls and women. Compelling evidence shows that women are more sensitive*

> *to context so we need to develop the cyber-physical and offer a richer content […] We need to create female-friendly designs and production to increase women's engagement and participation, and improve female representation in STEM" argues Elizabeth Pollitzer, Director of Portia Ltd., adding "In the year 2000 gender imbalance in ICTs was a big issue and the UK government was keen to retain and attract more women in the field. In fact, this was the original motivation for setting up Portia in the UK, an organization for advancing the quality of research and innovation through the gender dimension*".

Elizabeth founded the *Gender Summit* https://gender-summit.com/ which she organizes annually. It is a platform where scientists, policymakers, gender scholars and stakeholders in science systems work together to achieve gender equality in STEM, in research and innovation. The Gender Summits have brought together over 5.000 participants from industry, STEM, and science scholarship from Europe, North America, Latin America, Africa and Asia-Pacific. The Gender Summit started in Europe in 2011, influencing how gender is addressed in Horizon 2020, the biggest EU Research and Innovation program ever with nearly €80 billion of funding available over 7 years (2014 to 2020).

"*Cultivate your leadership skills, and learn how to manage people. At some point, if your career progresses well, you will be a manager. You will not be able to do everything so learn to delegate. […] Decide what you want to do and then do it! Don't get side-lined in other jobs. Don't let anybody tell you that you cannot do what you have decided. Have confidence in yourself!"* advises Rosalie Zobel, former Director in DG INFSO (Information Society) Directorate C: Components and Systems—and former Chair of the High Level Group of the European Centre for Women in Technology (ECWT).

Rosalie contributed to encouraging hundreds of girls and women in ICT by working on policy to include women in the sector. Rosalie also fostered many concrete actions such as the setting up of the European Center for Women and Technology (ECWT), which was a DG INFSO C's director's team concept that materialized thanks to her support.

5. Conclusions: "*the digital divide is alive and well"*

Current studies comprising scenarios on how jobs and skill demand will be redefined in the next few decades indicate that the digital divide is growing and diversity in tech is lacking. Increasing diversity in STEM education while including the human dimension (soft skills) is critical for employment and employability, in addition to building the workforce of the future. Undeniably, it is vital to increase diversity in STEM education, while including the gender dimension, since gender stereotypes and social biases start at an early age. Although digital skills are becoming increasingly essential— in a world where 60% of all global GDP will come from digital sources by the year 2022—to meet the challenges of the 4IR, research shows "*the digital divide is alive and well."*[xi]

Exclusion from the digital market is augmented and reinforced when combining the gender dimension with other exclusionary factors, such as disability, age, race and socioeconomic background. The economic and social case for investing to bridge the digital skills gap, along with eliminating women's underrepresentation (gender gaps), could not be clearer, especially in view of the alarming percentages and data presented in the latest Global Gender Gap Report and Index (World Economic Forum Insight Report, 2019; World Economic Forum, 2018), other than previous studies confirming gender gaps and the need for gender parity (i.e. Everts, 1998; Warschauer, 2003; Foley, 2004; Kamberidou & Patsantaras, 2004, 2006; Pascall, 2012, 2008; Kamberidou, 2013; Ashcraft, McLain & Eger, 2016, Deloitte 2016, Mims 2017, Duke, 2018) Research and statistical evidence indicates we need to rethink the professional life model, bearing in mind that even women who are considered successful in the digital market economy are less satisfied with their careers compared to their male counterparts, the reason being they continue to confront gender discrimination, i.e. lag behind men in compensation and advancement.

Additionally, alarming are the declining rates in the proportion of women earning degrees in computer science in Europe and the United States, indicating that efforts and interventions to attract, recruit and retain girls and women in ICT and STEM seem to be failing, or need to be intensified. Women employed in the tech industry have been leaving at overwhelming rates (leaky pipeline), a result of the glass ceiling and the work-life imbalance, depriving future generations of role models and mentors. Consequently, industry needs to eliminate gender pay gaps, promote qualified women to leadership positions, and raise the profile of female role models and leaders. Engendering ICTs and STEM entails women's engagement—agency and empowerment—not only as consumers and users, but as technology professionals, specialists, leaders, policy makers, producers, researchers, and entrepreneurs in a world with ever-increasing demands in ICT applications and services.

List of abbreviations

CEDEFOP - European Centre for the Development of Vocational Training
DESI - Digital Economy and Society Index
ESJ - European Skills and Jobs Survey (ESJ)
4IR – Fourth Industrial Revolution
GCSE - General Certificate of Secondary Education
ICT - Information and Communications Technology
ILO - International Labor Organization
OECD - Organisation for Economic Co-operation and Development
PIAAC - Programme for the International Assessment of Adult Competencies
STEM - Science, Technology, Engineering and Mathematics
WEF – World Economic Forum

Methods

What kind of digital skills are required in today's workplaces? Is the digital divide a result of social stereotypes? Where can we intervene to overcome barriers and begin eliminating social exclusions related to gender, race, class, disability, age and so forth? Why does the gender imbalance in ICT and related sectors persists today, despite decades of equal opportunity policies? Is it top priority to engender technology? Is it necessary to reshape STEM education to include the gender dimension? To address these questions this qualitative study examines the latest research on the digital skills crisis, focusing on the factors that contribute to digital exclusion. Building upon the latest research, through an in-depth analysis and critical assessment of the sources—44 scientific studies, articles, reports, dissertations—including the results and statistical evidence of 2018 Global Gender Gap Report and Index—the authors seek to identify gaps, and provide new perspectives while adding to existing knowledge on the gender dimension of the digital divide and women's underrepresentation in the 21st century (i.e. World Economic Forum Insight Report, 2019; World Economic Forum, 2018; Duke, 2018; Carayannis & Campbell, 2018; DESI, 2017; OECD/ILO, 2017; Cedefop, 2016; Raja, 2016; House of Commons 2016; World Bank, 2016, 2011; Warschauer, 2003; Kamberidou, 2013; Pascall, 2012). The authors argue that engendering ICT and STEM education and raising the profile of female role models and leaders is essential to inspire more girls and women into technology and reproduce participation. Engendering ICTs and STEM entails women's engagement, not only as consumers and users, but as technology professionals, specialists, leaders, policy makers, producers, researchers, and entrepreneurs. Accordingly, following the literature review and discussion, this paper provides a sample of recommendations by three inspirational role models and mentors, three successful women in ICT, STEM and Information Society. The semi-structured interviews allowed more flexibility to probe, discuss more openly, conduct follow-up meetings, and gain a better understanding. A sample of their recommendations-observations is presented before the conclusions.

Competing interest

The authors declare that they have no competing interests

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Disclaimer

The views and opinions expressed in this chapter are those of the authors and do not necessarily reflect or represent those of their institutions.

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[i] Special thanks to the artist Areti Kamperidis for her contribution titled "Engendering technology-empowering women". Areti was born in Toronto, Canada, raised and educated in Boston, USA and is now living in Athens, Greece where she also studied at Southeastern University and Deree, the American College of Greece.

[ii] With regard to the EU, only a slight improvement observed in the number of Technology, Engineering and Mathematics (STEM) graduates in 2014 (19 graduates per 1000 people aged 20 to 29 years old) as compared to 2012 (17 graduates) and in the share of ICT specialists in the workforce: 3.6 % in 2015 as opposed to 3.2 % in 2013 (DESI, 2017).

[iii] International Labor Organization

[iv]See NCWIT Fact Sheet https://www.ncwit.org/ncwit-fact-sheet. The National Center for Women & Information Technology (NCWIT) is a non-profit community of more than 1,100 universities, companies, non-profits, and government organizations nationwide working to increase girls' and women's meaningful participation in computing (last accessed Oct. 20, 2019).

[v] General Certificate of Secondary Education (GCSE), an academic qualification, generally taken in a number of subjects by pupils in secondary education in England, Wales and Northern Ireland.

[vi] Data before Croatia's inclusion: today EU 28.

[vii] Adult employees, 2014, EU-28: 'How would you best describe your skills in relation to what is required to do your job? Please use a scale of 0 to 10 where 0 means your level of skill is a lot lower than required, 5 means your level of skill is matched to what is required and 10 means your level of skill is a lot higher than required.' Responses are conditional on level of ICT use needed in the job as identified in a prior question of the survey, etc. Source: Cedefop European skills and jobs survey.

[viii] The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Union takes part in the work of the OECD (Elliott, 2017).

[ix] Report prepared by the Centre for Entrepreneurship, SMEs, Local Development and Tourism (CFE) of the Organization for Economic Co-operation and Development (OECD), is part of a project undertaken in co-operation with the United Kingdom Commission for Employment and Skills (UKCES), the Australia Department of Education and Training, and the International Labour Organization (ILO). This project is coordinated by Jonathan Barr (Head of the Employment and Skills Unit, OECD LEED Programme) as part of CFE's Local Economic and Employment Development (LEED), Program under the direction of Sylvain Giguère, Head of OECD LEED Division.

[x] A composite index summarising indicators on Europe's digital performance. Four dimensions are examined the second of which is Human Capital and digital skills. European Commission: https://ec.europa.eu/digital-single-market/en/desi Accessed 6 Feb 2018. As regards DESI 2019, accessed Oct. 20, 2019, "over the past year, all EU countries improved their digital performance. Finland, Sweden, the Netherlands, and Denmark scored the highest ratings in DESI 2019 and are among the global leaders in digitalisation. These countries are followed by the United Kingdom, Luxembourg, Ireland, Estonia, and Belgium. Some other countries however still have a long way to go, and the EU as a whole needs improvement to be able to compete on the global stage." https://ec.europa.eu/digital-single-market/en/desi.

[xi] A phrase coined by Konstantinos Pouliakas, expert at the European Centre for the Development of Vocational Training (Cedefop, 2016).