NGI THINK NEXUS

White Paper

Empowering Women in Tech

July 2020

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Think NEXUS, an EC-funded project, aims at reinforcing EU-US collaboration on NGI-related topics in three focus areas: Science and Technology, Innovation and Entrepreneurship and Policy. The aim is to boost strategic research, industrial partnerships and policy compliances in order to gain socio-economic benefits in both the EU and US regions.

In the framework of this project, we are regularly publishing several short articles aiming at comparing the US and the EU approaches in different topics of NGI. The present document is focusing on Artificial Intelligence.

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Foreword

"More women can and must have re-warding careers in tech, and European tech needs to benefit from women's skills and competences". Such statement, extracted from the vision of the European Commission in its Digital Strategy for the period 2020-2025[1] - which is one of President von der Leyen's flagship initiatives-, must be seen as a transverse priority across the four streams of action shaping such agenda. Gender inequality represents a clear challenge for the Next Generation Internet, that requires balancing and reinforcing the digital competences and literacy of women to succeed in an increasingly digitalised and fast-changing labour market. To become a trusted digital leader rooted in values of openness, fairness, diversity, democracy and sustainability, Europe must undertake the commitment to **empower women in tech**.

This white paper reviews and compares the state of digital empowerment for women in Europe and the United States, relying on contributions exclusively from female digital leaders in the sector of NGI.

The EU perspective

The initiation of women in technology and computer science can be tracked back to World War Two (WWII), when Grace Hopper, a mathematics professor and navy officer, created a first complier programme which paved the way for modern coding language. During WWII, hundreds of women were hired by the military to solve complex calculations and improve the accuracy of weapons. Towards the end of WWII, a group of women was working for a top-secret project, which consisted of the development of an electronic numerical integrator and computer (ENIAC) – modern computer's prototype.

After WWII, the Science, Technology, Engineering and Mathematics (STEM) field experienced a growth phase and in the 1950s and 1960s many women worked on building software (seen as mindless background work), while men were specialised in hardware engineering. In 1967, the Cosmopolitan magazine published an article advertising computer science as an exciting career choice for women, which represented the start to the first big increase of women in tech. Over the 1970s, the number of women majoring in computer science degrees steadily increased and by 1984 it accounted for 37% in the U.S. and Europe (nearly twice of what it is today).
However, in the 1980s, the computer revolution brought the software engineering back to men. The technology field shifted and due to emerging cultural stereotypes and lack of attempts to balance the gender and wage gap, the field became extremely male dominated.

1 Shaping Europe's digital future". European Commission, 2020: https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf

Pop culture portrayed nerds and computer geniuses solely as men while women appeared in media as product models and 'perfect wives'. Men like Bill Gates or Steve Jobs became icons of the expanding industry; while the image of women in tech and computer science was lacking.

Today, the number of female computer science majors holds steadily at around 17%, and only about a quarter of all STEM jobs are occupied by women worldwide. Women are leaving the tech world at twice the rate as men and there is a visible underrepresentation of them in science, technology, and engineering[2] .
This insufficient number of women in STEM fields has complex, multi-aspect explanations. Many studies suggest that the reality of discrimination, male favouritism, judgement, salary disadvantages or the need to fight the stereotype and labels is prevalent and hindering the expansion of women in tech. Women often say they are discouraged and feel inadequate or misjudged – told they are not fitting the 'men's world'.

The European Commission (EC) and other European organisations increasingly recognise and highlight the existing gender gap in technology. There are plenty of long established and new regulations, campaigns and policies designed specifically to reduce the imbalance, and to invite, encourage, and support the role of women in technology and science. More and more resources are offered to promote fair employment, increase the interest of girls to pursue STEM careers and to tackle the unfairness and discrimination (European Commission, 2019).

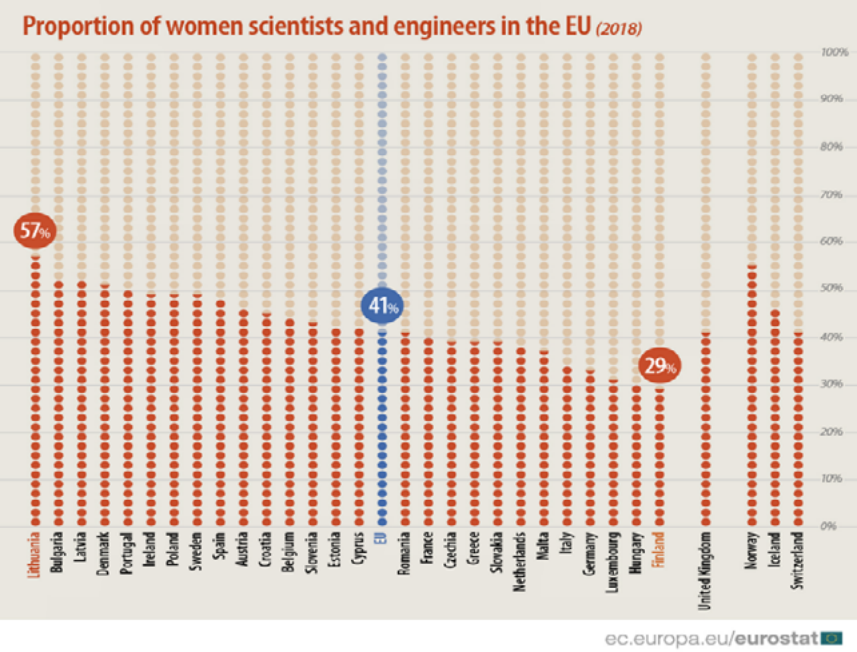
Women in technology and science in the EU

There are over 15 million scientists and engineers in the European Union (EU)[3] . And while nowadays more and more women enter STEM fields and the ICT (Information and Communications Technology) market is booming, men still fill most of the technology-related jobs in the EU. In 2018, the proportion of women in engineering and science in the EU accounted for 41% (Eurostat, 2018).

Eastern European countries such as Lithuania (57%), Latvia (52%) and Bulgaria (52%) are leading countries regarding the number of women employed in STEM; having even more females than males employed in certain sectors (e.g. science and research) (Figure 1). These statistics are noticeable as in comparison with Japan – the country known for its technological advances – where only 13% of all software designers and coders are women, which is less than half of the number of Bulgaria's ICT female workers (32%)2. According to the available datasets, in Finland, Luxembourg, Hungary and Germany only 1 in 3 technology and science employees are women.
When it comes to the distribution of women who work as specialists in the ICT market in the EU, the statistics are even lower. Women represent only about 16.7% of the ICT workforce in the EU (EDJNet, 2018).

2 "Women in Tech by Country". European Women in Tech, 2019: https://www.europeanwomenintech.com/blog/women-in-tech-by-country
3 "Women in science and technology". Eurostat, 2018 : https://ec.europa.eu/eurostat/web/products-eurostat-news/-/EDN-20200210-2

Figure 1. Proportion of female scientists and engineers in the EU (Source: *Eurostat)*



The EC's study: *Women in Digital Scoreboard*, which assessed the EU countries' performance in terms of women's participation in the digital economy, confirms that the largest gender gap occurs in the ICT specialist positions. This study, together with the Atomico study on "The State of European Tech", further indicates additional factors contributing to the following findings:

- only 34% of STEM graduates are women;
- women in the ICT earn on average 19% less than men;
- almost half of the female participants experienced discrimination in the tech sector;
- only 1 in 5 participants of tech Meet-ups were women;
- 93% of the capital invested in tech companies went to all-male founding teams (Women in Digital Scoreboards, 2019; State of European Tech, 2018).

In 2018, the significant gender disparity in the technology sector was also confirmed by the Women in Tech Index, which analysed 41 countries in the EU and the Organisation for Economic Co-operation and Development (OECD).
In addition, according to data from Eurostat, males graduating in science, mathematics, computing, engineering, manufacturing, and construction, outnumber female graduates almost two to one. Even though there are more female students entering higher education overall, it is not represented in STEM majors.

Initiatives, policies, and organisations supporting European women in tech

The EU and non-governmental organisations continue to create platforms, campaigns, and regulations to balance the inequality in the technology and science market. These entities advocate for closing the gender and salary gaps in STEM, and aim to encourage more female students to choose technology etc. The table below provides examples of these initiatives (Table 1 provides examples of these initiatives).

Table 1. An overview of example policies, campaigns, and initiatives supporting the women in tech in the EU.

Initiative / Policy / Campaign	Goals and mission
#DigitalRespect4Her	Campaign launched by the EC to raise awareness about online aggression aimed at women in tech and to promote respect and good practices to resolve the problem of cyber bullying.
European Network for Women in Digital	Platform promoting higher participation of girls and women in tech related studies and careers across the EU. Tackling gender stereotypes, supporting diversity in STEM fields, and providing resources for girls and women interested in ICT, engineering etc.
Member States' Declaration of commitment on women in digital	Twenty-seven EU ministers and Member States' representatives plus Norway signed the Declaration of commitment on Women in Digital at Digital Day on 9 April 2019. Raising the political priority of women's under-representation in the digital economy.
Declaration on an inclusive company culture	The declaration signed online by ICT CEOs aiming at closing the gender gap and providing an inclusive and gender-balanced work culture.
No Women No Panel	Campaign to bring awareness to the composition of scientific and tech panels.
Women in Digital	Platform supporting higher female participation in technology and providing evidence and estimates of the boost of the economy when more women in tech are recognised, included, and supported.
Girls in ICT Day	The international day of Girls in ICT suggested and implemented by the International Telecommunication Union to empower and encourage girls to choose STEM careers.
European Women in Tech	The biggest EU conference celebrating successes and innovations engineered and owned by women from across the tech industry. Supplying women with tools, knowledge, endorsement, and networking opportunities.
WEGate: European Gateway for Women's Entrepreneurship	Providing up-to-date information, resources, career and networking opportunities for women entrepreneurs who own businesses and start-ups, mostly in tech and ICT.
European Centre for Women in Technology	The partnership of more than 130 organisations representing high-level expertise in women and technology development from government, business, academia, and non-profit sectors working together to increase the number of girls and women in technology and ICT in specific.
EU Prize for Women Innovators	This prize recognises women entrepreneurs who have developed and brought an outstanding innovation to the market.

The U.S. perspective

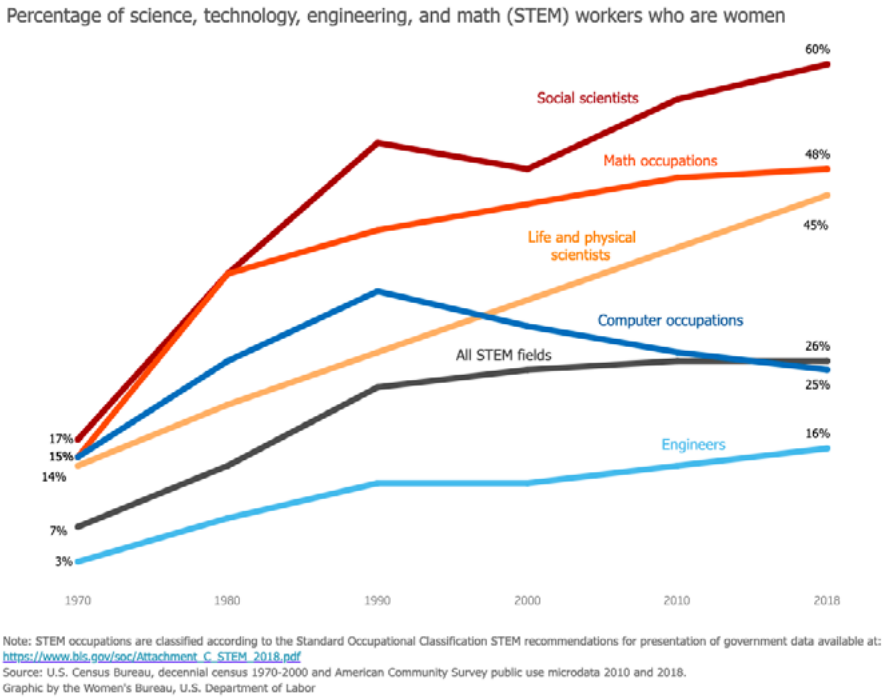
In "Shaping Europe's Digital Future", the EC states that "digital society should be fully inclusive, fair and accessible for all". Thus, one of the EC's goals is that "more women can and must have rewarding careers in tech, and European tech needs to benefit from women's skills and competences". In this sense "the digital transition must be fair and just and encourage women to fully take part".

The aspiration to have the digital society be fully inclusive, fair and accessible for all is equally appropriate for the U.S. This will allow better leverage of a country's human resources to develop the future, bringing multiple perspectives to address the challenges and opportunities, and harnessing latent STEM capabilities and interest across the population. While we have made progress, there is more to do.

Women have been a minority in tech in the U.S. forever. The U.S. Department of Labor statistics in Figure 1 show that women were 38% of the total U.S. labour force in 1970, yet only 15% of the labour force in computer occupations. Women as a percent of the labour force in computer occupations rose, to a historical high of 34% in 1990, only to decline steadily to 25% in 2018[4] . Considering engineering as another field of technology, women represented 3% of the engineering labour force in 1970 and rose to 16% in 2018.

Overall, women represented 51% of the total U.S. population in 20186, and 46% of the total U.S. labour force by 2016. While the historic underrepresentation of women in STEM fields is apparent in these figures, we have made good progress. Yet, there is more opportunity to better engage and retain women in STEM professions.

Figure 2. Women % of STEM workers (Source U.S. Census Bureau)

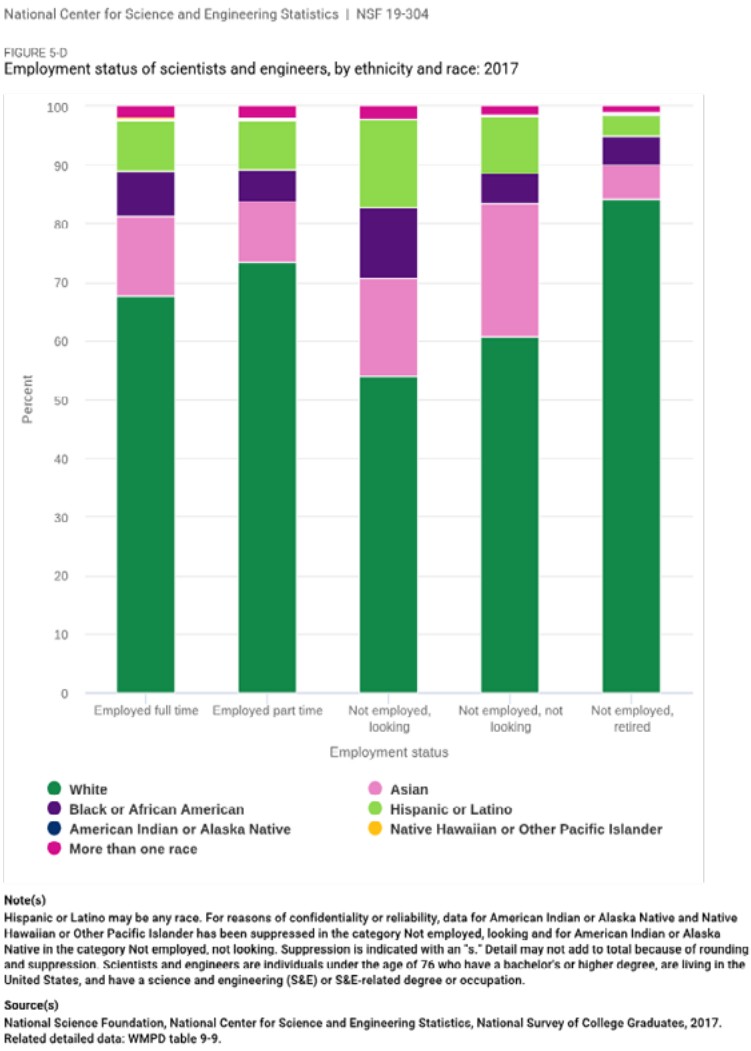


Note: STEM occupations are classified according to the Standard Occupational Classification STEM recommendations for presentation of government data available at: https://www.bls.gov/soc/Attachment_C_STEM_2018.pdf
Source: U.S. Census Bureau, decennial census 1970-2000 and American Community Survey public use microdata 2010 and 2018.
Graphic by the Women's Bureau, U.S. Department of Labor

STEM employment by ethnicity and race[5] in Figure 2 shows the minority perspective in 2017. White individuals represented almost 73% of the U.S. total population[6] , 67% of full time employees in STEM, and 73% of part time STEM employees. Meanwhile, Asians were 5.4% of the total U.S. population but represented 13% of full time employees in STEM, and 10% of part time employees in STEM, approximately double their census population percentage. Hispanics represented 18% of total U.S. population, but just 8% of full time and part time STEM employees, half of their overall representation in the population. Similarly, Blacks and African Americans represented 14% of the overall U.S. population, but only 7% of fulltime and 5% of part time employees in STEM.

4 "Women in the Labor Force". U.S. Department of Labor, 2018: www.dol.gov/agencies/wb/data/facts-over-time/women-in-the-labor-force
5 "National Survey of College Graduates". National Science Foundation, National Center for Science and Engineering Statistics, 2017. Related detailed data: WMPD table 9-11: https://ncses.nsf.gov/pubs/nsf19304/digest/employment
6 "ACS Demographic and Housing Estimates". U.S. Census Bureau, 2018: https://data.census.gov/cedsci/table?d=ACS%205-Year%20Estimates%20Data%20Profiles&table=DP05&tid=ACSDP5Y2018.DP05

Figure 3. STEM Employment by ethnicity, race
(Source: National Science Foundation)



As we look to increase the number of minorities working in technology fields, to be part of the teams developing new innovations and expanding the use of advanced technologies such as artificial intelligence, big data and analytics, machine learning, the Internet of Things, distributed digital ledger technology, and cybersecurity, we need more women and people of colour to enter and remain in the workforce. We need diversity of thought and experience to identify challenges to address, and develop the solutions, and new opportunities to advance our capabilities in technology and society.

There has been good progress this century in increasing visibility of women in tech leadership. Recent examples include Ginny Rometty being named Chairman, President and CEO of IBM in 2012[7] . In September 2014 Megan Smith was appointed the U.S. Chief Technology Officer by President Barack Obama[8] .

7 "Women In Tech: Inconvenient Truths And Changing Perspectives". Forbes, 2019: https://www.forbes.com/sites/julianvigo/2019/02/23/women-in-tech/#644af5bf45d7

8 The White House President Barack Obama, 2014, https://obamawhitehouse.archives.gov/blog/author/megan-smith

In 2016, the movie Hidden Figures told the true story of three brilliant African-American women at NASA -- Katherine Johnson, Dorothy Vaughan and Mary Jackson - who were the mathematicians and "computers" who programmed the first mainframe computers at NASA, and were responsible for the mathematics and coding behind the successful launch of astronauts Alan Shepard in 1961 and John Glenn in 1962[9] .

Even after NASA began using electronic computers, Astronaut John Glenn requested that Katherine Johnson personally recheck the calculations made by the new electronic computers before his flight aboard Friendship 7 – the mission on which he became the first American to orbit the Earth. Having worked at NASA in 1979, and later as IBM Vice President of marketing and strategy for the mainframe, the contributor to this paper Florence DiStefano Hudson12 was shocked in 2016 to learn of the story of these brilliant women. Sadly, their story was not told for many years as they were truly hidden figures.

When the media, industry, government and academia increase awareness of successful inspirational women, we increase the motivation of young girls and women to pursue their dreams in these exciting fields. Role models deliver a subliminal message - If I can do it, so can you. As President Barack Obama remarked after Sally Ride's passing at the age of 61, "Sally was a national hero and a powerful role model. She inspired generations of young girls to reach for the stars"[10]. Sally Ride along with other astronauts were role models for the U.S. contributor for this paper, a number of whom she was fortunate to have met as shown in Figure 3.

Figure 4. Meeting role models inspires women and minorities in tech (From Left: Florence DiStefano Hudson with Astronaut Alan Bean 1976; with Sally Ride, First American female astronaut c1977 at a Society of Women Engineers (SWE) conference; with Sally Ride and Florence's daughter Kristen Danielle Hudson c2003; with Astronaut Bonnie Dunbar and Kristen Danielle Hudson in 2005; with Mae Jemison, First African American female astronaut in 2017).

Organisations supporting women and minorities in tech have been growing, increasing connections to role models and mentors, and nurturing a sense of "belonging". Organisations such as the **Society of Women Engineers (SWE)**, the **Grace Hopper Celebration of Women in Computing**, the **National Society of Black Engineers (NSBE)**, and the **Society of Hispanic Professional Engineers (SHPE)** are a few examples.

9 "Katherine Johnson Receives Presidential Medal of Freedom". NASA, 2015: www.nasa.gov/image-feature/langley/katherine-johnson-receives-presidential-medal-of-freedom[13] "Her-story, Florence DiStefano Hudson". BridgeBizSTEM, 2015: https://bridgebizstem.wordpress.com/2015/08/31/her-story-florence-distefano-hudson-2/

10 "Sally Ride, first US woman in space, dies at 61". Yahoo Life, 2012: https://www.yahoo.com/lifestyle/sally-ride-first-us-woman-space-dies-61-214631931.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAGzxQRC19owXmJBDsByuB2GD7gA4tr12quy6SELz0Yj9QxsGkvqtihPYyTmXGz_mBq5_cjovatWuDxtCBWT_H4f6KC53XlcWuD6-KIVPuLON6DKYb-3EETZsX_e-neruyYjfET43PloaVJZ44tbovWSJ-k6icFiWfGckAu-eHkBu

SWE has grown from a gathering of the founding group of 50 women engineers and scientists in 1950 to a global conference in 2019 with 14,000 participants. NSBE had over 14,000 participants in their 2019 conference. The Grace Hopper Celebration of Women in Computing attracted 25,000 attendees in 2019. In the COVID-19 era, some of these conferences are going virtual. We should take this opportunity to reach and attract even more minorities to participate virtually and be inspired.

Diversity in engineering and tech organisations have strong and growing junior programmes to inspire students of all ages to become engineers and enter technical career paths. **SWEnext** and **NSBEjr** encourage children and students of all ages to explore the joy of engineering and tech. These efforts are helping increase the staying power of women and minorities in tech. But there is more to do.

First, we need to encourage and support more women and minorities to enter technical fields. The diversity in engineering organisations such as SWE, NSBE, and SHPE support that, but the culture in the institutions both for education and work need to be inclusive to maintain participation. Second, once we educate and encourage them to enter technical fields, we have to help them stay in the field. This is a cultural, and an operational challenge. In the U.S. workforce, more men than women were employed full time in 2017 in science and engineering, (12.8 million men versus 10.1 million women) and about twice as many women than men were employed part time (2.9 million women versus 1.5 million men).

When asked why they were working part time rather than full time, 45% of the women engineers and scientists working part time said it was due to family responsibilities, while only 19% of the men cited family responsibilities as the reason. Looking at reasons for not working, women are much more likely than men to report family responsibilities (27% versus 6%)[7]. There is an expectation, and therefore a need, for women to take care of the family. The lack of affordable childcare is one of the challenges.

Cultural expectations have strong effects on women not working in technical fields, perhaps much stronger than the lack of affordable and accessible childcare. Interestingly, women are a slightly higher percentage than men of minority college students in tech[11] . The downstream effect of cultural and childcare impacts perhaps speak to why fewer women than men work full time in the science and engineering fields as described above.

To improve STEM education and support for women and minorities, in 2017 the U.S. National Science Foundation launched a new program focused on Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES). It is a comprehensive effort to enhance U.S. leadership in science and engineering discovery and innovation by proactively seeking and effectively developing science, technology, engineering and mathematics (STEM) talent from all sectors and groups in our society.

NSF INCLUDES is one of the 10 “Big Ideas” for Future NSF Investment. By facilitating partnerships, communication and cooperation, NSF INCLUDES aims to build on and scale up what works in broadening participation programs to reach underserved populations nationwide.
The Director of the National Science Foundation from March 2014 through March 2020, Astrophysicist Dr. France A. Córdova, announced NSF INCLUDES in 2017, stating “Our nation’s future prosperity relies on advancing the frontiers of science – and reaching our full potential requires including all Americans in that effort,” as shown in Figure 4[12] ,[24].

Figure 4. Dr. France A. Córdova announced the NSF INCLUDES Program in 2017
(Source: National Science Foundation)

Discussion

The overall picture of women in tech in Europe is not ideal. While nowadays women remain a skilled, highly educated and an equal group in many sectors of life and labour markets, there is still a significant disproportion when it comes to the technology and science field. There is a consensus - reflected in many attempts and initiatives across the EU and the technology industry as a whole. Thus, Europe needs more scientists, specialists, and technicians in the STEM field (European Commission, 2004).

At least half of them should be women – to close the gender gap, tackle discrimination and balance the opportunities. To emphasise such need even further, it is estimated that the European GDP could be boosted by about 9 billion euros a year if more women worked in the tech sector (EurActiv, 2016). On top of that, it is suggested that around 10 trillion euros could be added to the global GDP by 2025 by advancing women’s equality (McKinsey, 2018).

There is a lot that needs to be done on multiple levels to bring out the real value of having more women involved in the EU tech industry. Young women need to be encouraged, supported and more visible in the technological innovations and the general message needs to change. The stereotypes about ICT belonging to men and inability of higher levels of the ICT world to simply communicate with female colleagues need to be ended once and for all.

11 “Undergraduate enrollment”. National Science Foundation: https://ncses.nsf.gov/pubs/nsf19304/digest/enrollment
12 “List of NSF Directors”. National Science Foundation: https://www.nsf.gov/od/nsf-director-list/nsf-directors.jsp

Women should not only be encouraged and rewarded on the same level as their male colleagues, but also actively involved, praised, and seen as an advantage and booster to the industry. The education systems should also pay more attention to better female acquisition for STEM classes, majors, and degrees.

While the rate of females graduating in STEM subjects has been slowly increasing, which is great to see – it is not enough; we observe that as the number of tech and science programmes has increased so has the number of male graduates meaning that too little has changed to overall representation of female STEM students (Women Tech Network, 2019).
The women who enter STEM fields need more support on the policy and legislation level, more media interest and presence to change the stereotypes, increased political and business leadership opportunities and more stimulating environments.

The discrimination and bullying must be removed together with other social and psychological obstacles which still stop women from believing in their success in tech. Reorganisation of values and assessment of human potential, recruitment procedures, management and reward styles, and deeply rooted beliefs must all respond to the call of closing the gender gap and finally seeing women leading in the technology and science.

With better awareness of the issues, more aggressive and efficient policy making, understanding of the underlying factors, more dialogue, and shifting the 'male-nerd' paradigm in the tech environment to be safer and more welcoming for women - the times of the prosperous, fresh and thriving tech Europe which will be supplied, supported and led by more women, are closer than we think.

Opportunities

The EU and the U.S. have the opportunity for mutually benefitting from an increase in women in tech. Their collaboration in science and tech propels science and discovery forward. Diversity of thought will yield more innovations with practical applicability across a larger and more diverse population and set of challenges. An increase in the number of tech educated and available individuals of all races and genders will help us better and more quickly leverage the technical innovations changing our world today, including the Internet of Things, Big Data analytics, Data Science, Artificial Intelligence (AI), Machine Learning (ML) and quantum computing.

Collaborative efforts between the U.S. and EU to increase programs that fund women in Next Generation Internet can make a difference. Public private partnerships of government, industry, academia, and not for profit programmes –such as **NGI Explorers**, the EU fellowship programme to support researchers and innovators to grow, learn and thrive in tech with U.S. partners–, have the potential to increase the awareness of society's support for women in tech and entrepreneurship, helping them achieve their goals in these fields. Together, we can transform the inequalities of the digital economy, reinforcing the competitiveness of new generations no matter the gender.

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825189. This publication reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains