On Promoting Gender Balance in Engineering

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The figures

Despite the significant strides made in gender equality, there remains a significant gender imbalance in STEM (Science, Technology, Engineering, and Mathematics) fields, with women being underrepresented at every level, from undergraduate degrees to leadership positions.

According to the *UNESCO 2030* [1, 2], women hold 53% of the world's bachelor's and master's degrees and 43% of PhDs. These figures are inverted in STEM fields and particularly in engineering disciplines. While bright spots exist, such as Lithuania where 57% of engineering graduates are women [3], only 33% of graduates in STEM fields were women [2] in 2017. The difficulty in attracting girls to scientific studies is a widespread global problem [2]. Girls face several obstacles in pursuing STEM fields, such as a lack of encouragement, low confidence levels, and negative stereotypes. Research shows that girls often do not see themselves as capable of pursuing a career in STEM because of the "pervasive cultural perception that women are unable to do science" [4]. The lack of recognition and difficulties in finding a job after graduating may discourage women from pursuing a career in engineering. Indeed, the gender gap extends beyond graduation rates and into employment. A concerning statistic of the United States Census Bureau shows that only 16% of female graduates in STEM find jobs in their field, which is 20 points lower than their male counterparts [5]. This implies that 84% of female graduates in STEM either move to other sectors or simply do not find jobs.

These numbers also remain inadequate when considering gender equality in scientific research and industrial development fields. According to the *She Figures 2018* report [6], women researchers remain underrepresented in the European Union, making up only 33% of researchers in 2015. Moreover, 41% of EU scientists and engineers are women (7.1 million) while 59% are men (10.5 million). These numbers have remained stable since 2012, indicating a lack of progress toward greater gender diversity in the field. Nevertheless, there are some encouraging examples showing that these numbers may be improved. The majority of female scientists/engineers are located in only five EU member states: Lithuania (57%), Bulgaria and Latvia (53%), Portugal (51%), and Denmark (50%). However, the Netherlands has the lowest proportion of women researchers (25.4%) followed by France and the Czech Republic. Globally, women account for only 29% of the workforce employed in scientific research and development, highlighting the urgent need to encourage more women to pursue careers in STEM fields.

The gender gap is even wider in academia. The press refers to the phenomenon as the leaky pipeline, where the higher up the academic ladder, the wider the gender gap. In 2016, women academics held 41% of academic positions across the 28 countries of the European Union (EU-28) but accounted for only 24% of senior academic positions and 22% of heads of higher education institutions in 2017. For example, currently only 10 University Rectors out of 85 are women in Italy.

In summary, although the number of women graduates are, worldwide, higher than men graduates, this trend is inverted for STEM and particularly engineering disciplines. We observe difficulty in involving girls on the path of scientific studies and the phenomenon that many graduate women in engineering change their field or even do not work. Efforts should be made to encourage girls to

pursue STEM education and provide equal opportunities for women in employment and academia. Only then we can achieve true gender equality and make use of the full potential of our workforce.

The reasons to care for gender balance

The initiative for gender balance in engineering and STEM fields has been gaining momentum in recent years. Women represent a significant talent pool that is currently underrepresented and the obstacles preventing women from pursuing STEM fields need to be addressed.

Many studies have demonstrated the necessity for gender balance. Not only are women being left out of the highest-paying jobs in STEM, but companies are affected as well. Instead, research shows that gender-diverse teams make better business decisions than teams that are all-male and that there is a correlation between the number of women in engineering and the higher gross domestic product (GDP) [7]. In particular, it was estimated that Europe's GDP could improve by closing the gender gap and that achieving gender equality could add up to 1.2 million jobs in the EU and 800 billion EUR (the GDP of an average size European nation) to the EU's GDP by 2050 [8].

Engineering fields are also key to potential revolutions in areas such as healthcare, education, and climate change. By promoting gender balance in these fields, we may ensure that diverse perspectives are included in the creation of innovative solutions. We should ask ourselves if we are willing to lose several potential talented researchers simply because of gender.

Policies for improving gender balance in engineering

Gender imbalance in STEM and engineering fields is a long-standing issue that many (male) researchers believe will solve by itself. However, we are losing an extraordinary economic opportunity by waiting. Efficient control policies are therefore needed to achieve gender balance more quickly than free response dynamics.

Fortunately, industrialized nations such as the European Union state members and the United States have adopted policies and funding incentives to increase the participation of women in science. The Science and Engineering Equal Opportunity Act of 1980 in US mandates equal opportunities for men and women in scientific/technical fields while the US National Science Foundation ADVANCE program offers fellowships and awards to increase the participation of women in research excellence. The European Horizon 2020 (EU 2014-20 research & innovation program) implements a strategy to promote gender equality in research and innovation while the EU 2020-2025 Gender Equality Strategy presents policy objectives to make progress towards a gender-equal EU by 2025. The former EU Research Commissioner Carlos Moedas stated that EU should embrace gender quotas [9]. Indeed, it is well-known that the EU has been insisting on a 40% quota for women on company boards. However, past EU attempts to set this goal have been blocked by member states. At the primary/secondary school level, governments are implementing strategies such as appointing a gender champion, analysing progression data by gender for different subjects, training teachers to understand unconscious bias, raising students' awareness of gender stereotypes, establishing project-led science clubs that encourage gender balance, increasing the visibility of female role models, and discussing the breadth of STEM career opportunities.

Individuals may also actively contribute to improving gender balance in any field. Employers may modify hiring practices to increase diversity, encourage leadership roles for both men and women, implement equal pay, prioritize work-life balance, create an open-minded atmosphere, connect with

young people to promote engineering as a desirable career path, mentor and provide opportunities for others to mentor, promote educational and career opportunities focusing on gender balance, create gender-balanced panels for job interviews, and implement strict policies against harassment and workplace offense. Junior members may actively insist on closing the gender balance during their education and at the start of their careers, claiming credit for their ideas, participating in professional organizations and extra-curricular activities, investing time in extending their peers' networks, increasing their visibility and ideas/brand visibility, and being authentic.

Some success stories

There are success stories that prove that it is possible to achieve gender balance and equity. From companies that prioritize diversity and inclusion to women who have broken through the glass ceiling. These examples inspire hope and offer valuable lessons for organizations and individuals striving for gender equality.

Duolingo, a popular language-learning platform, is a company that has achieved a 50/50 gender balance. By prioritizing hiring from universities with a higher percentage of female majors, Duolingo has created a workforce that reflects gender balance. This approach demonstrates that companies can make a difference by working with universities that are actively promoting gender equality. Pinterest, the fourth most popular social media app, is also close to gender balance with 47% of its employees being women, including 30% of its engineers. The company has a Diversity Chief, who helps ensure that diversity and inclusion are at the forefront of the company's values and practices. By prioritizing these values, Pinterest has created a welcoming and inclusive workplace that promotes gender equity. LinkedIn, the professional social media site, has made significant strides in achieving gender balance. The company currently has 43% female employees, with 22% of tech employees and 39% of leadership roles held by women. LinkedIn's commitment to diversity and inclusion has resulted in a more gender-balanced workforce and leadership team. The gender equity research firm Equileap has published statistics on the world's leading multinational brands in terms of gender equality. The engineering company General Motors (GM) leads the ranking, as one of the very few companies that have been able to eliminate the wage gap. By analyzing salary data and ensuring pay equity, GM has created a culture of fairness and equity that promotes gender equality in the workplace.

Encouraging girls to pursue scientific studies and providing them with female role models helps break down negative stereotypes and build confidence. Moreover, addressing the unconscious bias that affects women in STEM fields and providing opportunities for recognition and advancement helps create a more inclusive and diverse scientific community.

Numerous women engineers have achieved success in their field. Samantha Cristoforetti, known as AstroSamantha, was the first Italian and third European woman astronaut in space. She holds a mechanical engineering degree and has inspired many young women to pursue careers in STEM fields. Ginny Rometti, the former IBM CEO for over eight years, holds a degree in computer science and electrical engineering. Marissa Mayer, who played a key role in Google for over a decade and served as CEO of Yahoo for five years, holds a computer science engineering degree.

These success stories demonstrate that gender balance and equity are achievable goals. By prioritizing diversity and inclusion, companies may create welcoming and inclusive workplaces that promote gender equity. By inspiring and supporting women in STEM fields, we can break the glass ceiling and achieve true gender balance in the workforce.

SMCS activities in gender equality

The IEEE Systems, Man, and Cybernetics (SMCS) Society established in November 2021 an SMCS Diversity and Inclusion (D&I) Committee, chaired by Prof. Mariagrazia Dotoli (Politecnico di Bari, Italy) until 2022. It is currently chaired by Prof. Ljiljana Trajkovic (Simon Fraser University, Canada). The missions of the SMCS D&I Committee are: aligning SMCS with IEEE's mission to create a diverse and inclusive membership, guiding SMCS in proposing new initiatives, and improving current programs to be diverse and inclusive. The current activities of the SMCS D&I Committee are: liaising and meeting with IEEE TAB Committee on D&I; developing a data collection template on D&I; collecting data on D&I in SMCS; and developing a D&I action plan for SMCS. The following actions for improving D&I have been identified: publicizing the existing D&I activities in the SMCS eNewsletter and SMCS website; developing outreach and networking activities on D&I at IEEE and SMCS events; developing mentorship activities in identified SMCS communities where D&I needs improving; and liaising with the existing IEEE activities and Women in Engineering.

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Author Short Biography

Mariagrazia Dotoli is a Full Professor in Automatic Control at Politecnico di Bari. She is currently the Vice President for Membership and Student Activities of the IEEE Systems, Man, and Cybernetics Society (SMCS). She was the 2021-22 Chair of SMCS Diversity and Inclusion Committee. She has been the Vice Rector for research of Politecnico di Bari and a member-elect of the Academic Senate. She has been a visiting scholar at the Paris 6 University and at the Technical University of Denmark. She is expert evaluator of the European Commission since the 6th Framework Programme. Her research interests include modeling, identification, management, control, and diagnosis of discrete event systems, manufacturing systems, logistics systems, traffic networks, smart grids, and networked systems.

Prof. Dotoli was Co-Chair of the Training and Education Committee of ERUDIT, the European Commission network of excellence for fuzzy logic and uncertainty modeling in information technology, and was key node representative of EUNITE, the EUropean Network of excellence on Intelligent Technologies. She is a Senior Editor of the IEEE Trans. on Automation Science and Engineering and an Associate Editor of the IEEE Trans. on Systems, Man, and Cybernetics. She is the General Chair of the 2024 IEEE Conference on Automation Science and Engineering. She was the General Chair of the 2021 Mediterranean Conference on Control and Automation, the Program Chair of the 2020 IEEE Conference on Automation Science and Engineering, the Program Co-Chair of the 2017 IEEE Conference on Automation Science and Engineering, the Workshop and Tutorial Chair of the 2015 IEEE Conference on Automation Science and Engineering, the Special Session Co-Chair of the 2013 IEEE Conference on Emerging Technology and Factory Automation and Chair of the National Committee of the 2009 IFAC Workshop on Dependable Control of Discrete Systems. She was member of the International Program Committee of 80+ international conferences. She is author of 200+ publications, including 1 textbook (in Italian) and 90+ international journal papers.