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Gender (im)balance in science and engineering across cultures

From Maria Merian to Mary Anning, from Henrietta Leavitt to Lisa Meitner, from Rita Levi-Montalcini to Chien-Shiung Wu, from Ana Aslan to Rana El-Kaliouby, what these women scientists and engineers have in common is that they have forever changed the way we see our world. However, it took far too long for their discoveries to be acknowledged and too often books and academic courses that explore the history of science neglect the remarkable, groundbreaking women whose work has changed the world. And to a certain extent, the situation is not very different for women in science and engineering nowadays.

The aim of this interactive lecture is to explore gender gaps leading to a career in science and engineering, from the decision to enrol in a degree, to the scientific fields that both genders pursue and the sectors in which they work. Moreover, the lecture sets out to outline the combination of factors which leads to the emergence of this gender imbalance at each stage of a scientific career: the graduate-level environment, performance evaluation criteria, the lack of recognition, lack of support for leadership skills development and conscious or unconscious gender bias.

The lecture focuses on both a national, as well as a trans-national and trans-cultural perspective of gender imbalance in science and engineering. Participants are encouraged to bring their own input on this topic, based on both their personal and cultural experience, as there are regions that encounter even more barriers as a result of cultural norms that discourage women from taking traditionally male roles, thus generating an even greater gender imbalance.

The final part of the interactive lecture aims to discuss policies for gender equality that have already been created and their efficacy, as well as other approaches that can be taken in order to ensure an equitable and diverse work environment in science and engineering.

Introduction. Transnational gendered challenges

Gender balance is more than just a question of justice and equity. Countries, businesses and insititutions which create an enabling environment for women increase their capacity for innovation and competitiveness, as they can benefit to a greater extent from the interaction of different perspectives and expertise, encouraging new solutions and expanding the scope of research. This should be regarded as a global priority and we should each contribute to the best of our ability to reaching this next set of development goals.

Regardless of where they live, women have a lot in common. For example, they are expected to get married to men and to have children. They are more likely to experience sexual and domestic violence than are men. Women's role as "reproducers", that is, their ability to bear and nurse children is a particularly important aspect that women share regardless of culture. Bearing and caring for children is a source of status and value for women and as it is one of the only areas in which women are believed to excel over men. Women are also responsible for their children in ways that men are not, and this affects their daily lives dramatically, regardless of where they live.

One important thing women have in common is that most of them live in patriarchal societies. In gender studies, **patriarchal societies** are defined as those with economic, political and legal structures that perpetuate gender inequality. Men generally control economies and political and legal systems and this has great implications for women worldwide. More specifically, it often means that women do not have the resources to live independently of men, to leave situations of abuse or to seek justice. It means that many countries do not have laws protecting women from gendered acts of violence and that those countries with such laws often fail to enforce them. It means that in many places, violence against women and the perception of women as men's property is common cultural practice and that women are conditioned to accept this.

The form and specifics of these commonalities may differ based on culture, but women undoubtedly share certain experiences due to their gender. These similarities form the basis of

transnational feminism, that cuts across cultures and unites women's struggles from many parts of the world. For instance, almost everywhere, women work extremely hard in both paid and unpaid labor, experience sexual harassment, get married, structure their lives according to their children's needs, worry about unplanned pregnancies, and are at higher risk for gender violence, such as rape, sexual assault or domestic violence.

While the majority of women worldwide live in patriarchal societies, there is great cross-cultural variation in the gendered challenges women face and how they face them. For instance, activists in:

- **The United States**: work on increasing the number of women in Congress by giving money to women's campaigns and lobby Congress to make emergency contraception available without prescription
- **Israel**: seek an end to Orthodox Jewish laws that allow only husbands to seek divorce
- **Japan**: work to increase the number of shelters and community supports for battered women
- **India**: fight for the enforcement of laws forbidding dowries where the bride's family must pay the groom's family
- **Pakistan**: aim to protect women from "honor killings", where male relative murder women to protect the family honor for such offenses as being raped
- **Afghanistan**: seek the prosecution of gunmen who have forced the closing of several girls' schools and have burned some down
- **The Dominican Republic, Brazil, Cambodia, Costa Rica, Burma, Thailand** and **Cuba**: work to prevent the "trafficking" of young girls and women into sexual slavery

While women's challenges and their response to them varies according to region, society and time period, when it comes to their insertion in the field of science and technology, women around the world seem to face the same challenges.

School environment and gender stereotypes in the STEM field

The statistics of education show that women outnumber men in college enrollment. However, women are underrepresented in science and engineering field both in terms of the number of bachelor's degrees they earn and their presence in the science and engineering workforce. Throughout the last half of the 20th century, activists fought to change that situation.

Gender segregation in the vocational orientation of adolescents has been well-documented for decades in most OECD countries. The persistence of gendered paths in career choices has recently been reflected in the current Global Gender Gap Report of the World Economic Forum (WEF), which states that on average men are underrepresented in the fields of education, health and welfare whereas women are underrepresented in the STEM.

The persistence of horizontal gender segregation in educational and occupational fields contributes decisively to the spread of gender-stereotypic beliefs about a natural fit of women in careers in more expressive and human-centered fields and men in technical and math-intensive fields.

Miller et al. (2015) conducted a survey of about 350 000 participants in 66 countries, which analyzed how women's enrollment in science courses relates to the gender-science stereotype. This study concluded that explicit and implicit national gender-science stereotypes were weaker in countries with a higher female enrollment in tertiary science education. This study also demonstrated that stereotypes about science were strongly gendered, even in countries with high overall gender equity. The low proportion of women in STEM leads to the spread of a gender stereotypical image of math and science as a male domain and beliefs about male supremacy in technical and math-intensive fields. In turn, such beliefs affect young people's career choices, leading to a mutual reinforcement of gender stereotypes, and gender gaps in career related interests and choices.

The **gender stereotype of math and science** has been analyzed via a variety of quantitative and qualitative methods. Among those are the **Draw-A-Scientist Test (DAST)**, **the Implicit**

Association Test (IAT), **explicit stereotype assessments** using **attitude questionnaires**, **semantic differential assessments** and **individual or group interviews**.

Studies that applied the DAST method reported that students from kindergarten to high school perceive a scientist as a male person. The children's drawings contained very few portrayals of female scientists and these few drawings were mostly drawn by female students. For example, in a study surveying students in grades 2–12 only 135 pictures out of 1,600 displayed female scientists and only six out of 135 pictures of a female scientist were drawn by male students.

Research on gender-science stereotypes has illustrated differences between female and male youth with respect to the endorsement of stereotypic beliefs about STEM. A study among primary school students illustrated that stereotypical beliefs that STEM school subjects are more suitable for boys than for girls were more strongly endorsed by boys than by girls. Especially boys who were highly interested and girls who were relatively uninterested in STEM-related school subjects were more likely to believe that STEM school subjects constitute a male domain.

Finally, a study among first-year university students indicated that negative stereotypes of women's engineering and mathematical ability were more strongly endorsed among male students, whereas female students were more likely to report higher perceptions of their engineering abilities.

There are several theories attempting to account for this status quo of women in science and engineering:

Theory of discrimination and denial of access

One is the **theory of discrimination, denial of access**. Engineering was perceived as a masculine career and consequently, women were denied access. Studies of elementary, middle and high

school science reveal a persistent pattern in which teachers paid more attention to boys' scientific interests and provide them with more science experiences. Girls, on the other hand, develop more negative attitudes towards science

Until World War II and beyond, many leading engineering schools, including Rensselaer Polytechnic Institute, Georgia Institute of Technology, and California Institute of Technology, remained closed to women. The few women admitted to Massachusetts Institute of Technology (MIT) struggled against a hostile intellectual and social environment. Women studying engineering were perceived as odd exceptions, outcasts and defying normal gender norms .

The reason for the gender exclusion was found in the origin of the profession. Throughout the 19th century, it was rare for practitioners to have earned a formal engineering degree. They acquired their credentials through on-the-job experience such as in the railroad yard, or machine shop. Such work environments excluded women. In addition, engineering chores involved hard, sometimes dangerous and physical encounters. These were perceived as inappropriate for women. Other forces that reinforced the masculinity of the profession were that makers of model trains and other technological toys marketed them only to boys as a way to make them into future engineers. Girls who expressed technical interests were often steered instead into the science side of home economics.

The issue of venturing into strange space came to a head when, with the outbreak of World War II, the United States suddenly faced a manpower crisis. Men were called up to service, and industry needed people with technical expertise at drawing boards and engineering shops to produce planes and tanks for the war. So, companies sought to hire female engineers. But they could not find enough female engineers. Companies like General Electric hired women with knowledge of Math and Science, gave them emergency crash courses and turned them into wartime engineers' aides. Life magazine published a special feature titled: "The 'engineeresses' were a curiosity, but acceptable as a temporary war measure".

As World War II drew to a close, returning male veterans flooded American engineering programs, and the wartime emergency rationale for encouraging women to develop their technical talents vanished. Also, conservative gender modes of the postwar decades brought a prevailing expectation that the goal of marrying and raising children should take precedence over women's career ambitions. Young girls who did express technical interests were often deliberately discouraged by negative remarks from family or teachers.

Theory of self concept

Another proposed theory is the issue of self concept. Ross & Nisbett argued that individuals see situations through the lens of their own self views and that individual differences exist in the way situations impact on people. Constructivist posit that humans actively create and construe our personal realities.

Female college students, even those who select math-intensive majors, have difficulty associating math with the self if they implicitly stereotype mathematics as masculine. Despite their current self-perceptions as positively inclined toward mathematics and science, women in one study could not, or would not construct possible selves in the realm of engineering and the physical sciences – perhaps because such possible selves were at odds with their notions about feminity, or perhaps because they had no female role models in these areas to help them articulate a possible self

Theory of family connection

One other theory being proposed as to why fewer women can be found in science, is that women make decisions about their lives differently from men.54, 55 These decisions are made with the mindset of having multiple life roles, self identity and ways of interacting with people, objects and experiences in the world.56 Nard57 found that women make career plans based on anticipated personal and professional roles. Gilligan.58 found that highly successful women

describe themselves in terms of relationships. Their identity rests with their relationship as mothers, wives, lovers and children and not in academic or professional success.59 Similarly, Arnold60 found that academically outstanding women tend to judge success in terms of relationships and tend to make decisions that emphasize balance between work and family life.61 Younger girls and adolescents also describe their world in terms of relationships.62 Eccles63 concluded that women may choose less technical occupations because of their popularity which makes choice less challenging than it is for other occupations. Women's choices are based on short and long term goals, self identity and psychological needs that are different from those of men. For many female students, the technical nature of engineering does not suggest life skills of creative thinking and communication.

Workforce

Education is not the only area that marginalizes women in science and engineering; workplace discrimination is a real barrier to women scientists. In industry, limited access is the first hurdle faced by women seeking jobs in science and engineering. While progress has been made in this area in recent years, common recruitment and hiring practices which use traditional networks often overlook the available pool of women, according to report of Committee of Women in Science and Engineering (CWSE). Once on the job, the environment is toxic to women. Many female employees find paternalism, sexual harassment, allegations of reverse discrimination, different standards for judging the work of men and women, lower salary relative to their male peers, inequitable job assignments, and other aspects of a male-dominated culture that are hostile to women. Women have limited opportunities for advancement, particularly for moving into management positions. The number of women who have achieved the top levels in corporations is much lower than would be expected.

Aspects of Gender Inequality for Women in STEM Careers in Romania

In Romania, the evolution of social life was very challenging, as the forced industrialization specific to the communist period did not allow a real change of the traditionalist relations between the sexes, while the emancipation of the woman was generally associated with her inclusion on the labor market.

The *European Gender Equality Index 2019*, ranks Romania 25th in the EU, indicating that Romania is progressing towards gender equality, but at a slower pace than other EU Member States. Moreover, the *Global Gender Gap Report 2020* ranks Romania 55th in the world, showing very slow improvement.

On the other hand, the *World Bank's Romania Gender Assessment Report* (2018) indicates a series of advances related to the presence of women in scientific fields considered male dominated and the creation of a legislative and institutional framework for addressing gender issues. Despite these advances, women are becoming more numerous in the NEET group (people who are no longer in the education system, but are neither employed nor follow any other form of vocational training) and the report is underlying the inequitable distribution of time for domestic activities among women and men. In the ICT field (mathematics, statistics, computing and engineering) , Romania is mentioned as a country with a smaller gender gap difference, despite the fact that the number of men population is almost three times larger.

Although there are a large number of women graduates in STEM areas compared to the other European countries, however, the number of Romanian women who complete doctoral level is really low, placing Romania in a cluster positioned on the penultimate place, only ahead of North Macedonia.

Gender Barometer. Romania 2018 points out a contradiction between the promoters of gender equality and the target population of these efforts: while 47.3% of women agree that "women often do not get jobs because they are women", yet 50.3% respondents agree that "gender discrimination is no longer a problem in Romania".

Conclusion

Women continue to be underrepresented in the fields of engineering, physical sciences, mathematics, computer science, and biological sciences. Women are also underrepresented in the scientific and technical workforce. The number of women in science and engineering is neither representative of the population, nor is it representative of the number of women educated in these fields.

We must continue to address the many but subtle ways in which women are discouraged from pursuing interest in scientific and technical fields. Society benefits most when we take full advantage of the scientific and technical talent among us. It is time we created a broader awareness of those proven and effective means, including institutional policies and practices that enable women and other underrepresented groups to step beyond the historical barriers in science and engineering.

Changes in classroom instruction, in teacher and parental expectations and in social perceptions are needed before equality for women in the classroom and on the labor market could be achieved. Through partnerships, school systems and institutions of higher learning can implement cost efficient and educationally effective programs that develop student skills and talents in high schools that prepare them for the rigors of college and university study, and that enable them to be competitive in the workplace.