EXECUTIVE SUMMARY

Study for FEMM committee

European Parliament

Education and employment of women in science, technology and the digital economy, including AI and its influence on gender equality[1]

This study, commissioned by the European Parliament's Policy Department for Citizens' Rights and Constitutional Affairs at the request of the FEMM Committee, provides evidence that there is still gender bias and inequality in STEM (Science, Technology, Engineering, Mathematics) fields and the digital sector (e.g., digital technologies, Computer Science, Information Technology, Information and Communication Technology, Artificial Intelligence, cybersecurity). This document, prepared at the request of the FEMM Committee (Policy Department for Citizens' Rights and Constitutional Affairs, Directorate-General for Internal Policies), is intended to provide an up-to-date literature review on the current status of women's education and employment in STEM fields and the digital sector. In so doing, the corresponding trajectories are examined, from the primary education level up to the employment level, in an attempt to identify obstacles and bottlenecks that prevent gender parity. Finally, suggestions for future research, initiatives and policies that would improve women's participation in these areas are made.

Secondary education

- Girls lag behind boys in math achievement, with adverse implications for their STEM attitudes.
- Girls tend to perform well on both math and verbal ability, compared to boys, who perform well in math only, which offers girls a broader range of possible options (i.e., career pathways), and results in girls being less prone than boys to choose STEM.
- Previous reform initiatives in Europe aiming to make the STEM domain more attractive to females failed to achieve their goal, either when they restricted the choices available to students (see the German example in the full report), or when they increased the options offered to students (see the Swedish example in the full report).

[1] Full study in English: https://www.europarl.europa.eu/RegData/etudes/STUD/2020/651042/IPOL_STU(2020)651042_EN.pdf

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Higher education

- Although there have been recent improvements in some trends, female participation in STEM and computer science throughout all levels of tertiary education still lags behind that of males.
- Female students in higher education display lower perceptions of their own abilities, while they tend to attribute responsibility and blame to themselves anytime they are not able to engage in activities to the same extent as their male colleagues.

Employment

- Encouraging trends have been documented for women employed as scientists and engineers, with a mean annual increase of 2.9% between 2013 and 2017, and in knowledge-intensive activities, where the proportion of women (around 44%) is much higher than that of men (around 29%).

The digital sector: Artificial intelligence and cybersecurity

- The gender gap concerning artificial intelligence and cybersecurity is the largest among all digital technology domains. The average percentages of females in artificial intelligence and cybersecurity, worldwide, are 12% and 20%, respectively.
- Both the artificial intelligence and cybersecurity domains still carry gender stereotypes and biases.

Main discussion points

Biological, individual, and socio-cultural determinants of the gender gap

- There are several indications pointing towards the primacy of socio-cultural factors over biological factors or factors at the individual level of reference in shaping STEM-related ability and interest. Individual choices are made within a wider socio-cultural frame, which means that the decisions of individual women and men cannot be examined in isolation, apart from socio-cultural contexts.

No magic wand to fix the gender gap

- The incompleteness of explanations at the individual level of reference is reflected in the ineffectiveness of interventions targeting individuals. Despite the positive effects, this type of intervention was found to decrease sense of belongingness in the sciences and increase self-reported social identity threat for female respondents.

Problematize the "leaky pipeline" metaphor

- Critical readings of the "leaky pipeline" metaphor and its assumptions of linearity and unidirectionality in people's career trajectories criticize (1) the normative paradigm of a supposedly deterministic series of subsequent stages that women have to follow; (2) its overt focus on the supply-side (i.e., what is currently offered within a largely masculine culture) and not the demand-side (i.e., women's needs and desires), which may be equally important or more important; and (3) the "normalization" of the male condition, according to which the female condition is to be measured and judged.

Create enabling environments in education and workplace

- Policymakers need to consider background socio-cultural conditions, which may create the main tendencies for female STEM attitudes and behaviours, as well as individual female preferences, which may align with socio-cultural norms or not. This implies that policies need to apply to the majority of women within societies, but not undermine individual agency and freedom of choice.

Multi-level approach needed to address the gender gap

- There is an urgent need for a multi-level approach in the EU, taken over by stakeholders, to address the gender gap in STEM, ICT, and computer science. This should involve planned interventions at: (1) a micro-level, referring to student-teacher interaction and peer interaction in schools; (2) a meso-level, with educational institutions changing themselves to provide enabling environments for female students, and targeting positive feedback loops leading to bottleneck effects; and finally, (3) a macro-level, with stakeholders collaborating to collect and analyse cohort data anchored in real-world contexts, allowing for cross-cultural comparisons and for devising and updating a toolkit with concrete tools and methods to combat gender disparities.

Policy recommendations

Macro-level

- Stakeholder experience of what works in closing the gender gap in STEM should be exploited to devise and update a toolkit for addressing gender disparities. It should include institutional arrangements, provisions for intergroup interaction between stakeholders and provisions for ingroup interactions within each stakeholder group. The toolkit needs to be developed and adopted by institutions that are responsible for administration, education and the workforce.

Meso-level

- Education and work environments all over Europe should be asked to make use of the toolkit described in the previous section and to provide their critical feedback, aiming to offer enabling background conditions so that the adverse effects of gender bias are minimized and female choices are not compromised.

Micro-level

- The reference materials used across all educational levels, textbooks, pedagogical content knowledge, pedagogical scenarios and instructional practice, all need to be problematized so as to identify existing gender bias and gender stereotypes in content, as well as in teacher-student interactions, that may hinder gender equality. At the same time, it is of paramount importance to select and streamline pedagogical approaches able to promote gender equity. To this end, inquiry-based learning can prove instrumental, especially when combined with nature-of-science approaches and socio-scientific is

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