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


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# Background information

**Study requested by:**

Committee on Women's Rights and Gender Equality (FEMM committee)

Policy Department for Citizens' Rights and Constitutional Affairs

Directorate-General for Internal Policies

- Persisting biases and inequalities in STEM fields and the digital sector
- New policies and initiatives must be considered to eliminate the gender gap

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# Overview of the report and focus of the presentation

**Report overview**

- Primary education
- Secondary education
- Higher education
- Employment
- Examples of gender bias and inequalities from the digital sector: The cases of artificial intelligence and cybersecurity
- Main discussion points
- Policy recommendations

**Focus of the presentation**

- Methods
- Adapted version of SWOT analysis
- Employment
- The digital sector (artificial intelligence and cybersecurity)
- Main discussion points (Positive feedback loops/bottleneck effects)
- Policy recommendations (research recommendations; Platform; participatory scenario development)

# Methods, literature review

**Literature review**

- SCOPUS
- Keywords: “Gender" and "STEM" or "ICT" or "information and communication" or “computer science”
- Scientific articles or reviews in international peer-reviewed journals published in English between 2010 and 2020 (search run on 25 February 2020)
- Excluded all papers published in non-citation-index journals
- List of 165 scientific articles
- Added another 20 documents (grey literature) suggested by the FEMM committee
- Final list: 185 references

**Artificial intelligence and cybersecurity**

- Google Scholar search & SCOPUS (citation-index and non-citation-index journals)
- Keywords: "gender" and "artificial intelligence" or “cybersecurity”
- Filter in methods
- List of 67 references

# Adapted version of SWOT analysis

## Results

- **Strengths**: Ingroup aspects among females promoting gender equality in STEM, ICT, and CS
- **Weaknesses**: Ingroup aspectsamong females hindering gender equality in STEM, ICT, and CS
- **Opportunities**: Intergroup aspects (interaction of females with students, parents or peers; institutional arrangements; initiatives by policy-makers or employees) promoting gender equality in STEM, ICT, and CS
- **Threats**: Intergroup aspects interaction of females with students, parents or peers; institutional arrangements; initiatives by policy-makers or employees) hindering gender equality in STEM, ICT, and CS

## Policy recommendations

- Build on “strengths” and “opportunities”
- Address “weaknesses” and “threats”

| | |
|---|---|
| **Strengths (ingroup aspects promoting gender equality in STEM, ICT, and CS)** | ○ Although women employed as scientists and engineers in the EU-28 (40.8%) remain fewer than men, there was a mean annual increase in the female proportion of 2.9% between 2013 and 2017, with the growth rate for women being higher than that for men.<br>○ In knowledge-intensive activities, there is a much higher proportion of women (around 44%) than of men (around 29%). |
| **Weaknesses (ingroup aspects hindering gender equality in STEM, ICT, and CS)** | ○ The percentage of women in ICT careers still remains relatively low, and it is currently below 2% of the women's total share in the European labor market.<br>○ Recent research in the USA documented that women holding a degree in CS or engineering were not as likely as their male colleague to persist in the workplace. |
| **Opportunities (intergroup aspects promoting gender equality in STEM, ICT, and CS)** | ○ Female respondents could be as motivated as male respondents for engaging in STEM, if not discouraged by gender bias.<br>○ Increasing female representation in teams enhanced team identification for female team members, facilitating their psychological attachment to and confidence in the team, and further, fostering collective efficacy and team performance.<br>○ Gender diversity was found to favor the potential for innovation for technological companies.<br>○ With regard to decision-making bodies and board composition, board gender diversity yielded higher firm performance when there was a critical mass of women on the board.<br>○ At the EU level, gender equality is expected to have a series of positive impacts on the GDP of the EU, the competitiveness and balance of trade of the EU economy, and job supply.<br>○ Comparing institutions established to close the gender gap in the USA and Europe, the repertoire of institutions in the USA is richer and involves engaging women at the individual level of reference, mentoring, and gender equality in the workforce.<br>○ In contrast to the grassroots origin of most initiatives in the USA, European institutions committed to promoting gender equality are more stakeholder-based and organized as networks of actors in a top-down fashion, lacking vertical connections to local contexts. |
| **Threats (intergroup aspects hindering gender equality in STEM, ICT, and CS)** | ○ Two major aspects reflecting gender discrimination are gender gaps in upper-level positions and salaries.<br>○ Current institutional arrangements to address family life do not fully compensate for all impact experienced by women.<br>○ Gender differences and unintended discrimination were detected in the delivery of social media ads for STEM careers.<br>○ Only six EU-15 members and another two EU-13 members have prepared guiding targets for gender balance in decision-making bodies. |

# Delivery of social media ads for STEM careers

- A field test revealed that an advertisement for STEM careers, which was designed to be gender-neutral in its delivery, was less likely to be shown to women than men (displayed less in female Facebook profiles)
- Display/delivery, not clicks: When women were shown the ad, they were much more likely than men to click on it
- Social media advertisers tend to bid more to advertise to women than men, specifically, about 5 cents more (female eyeballs are more expensive)
- Women were found to be more likely to "convert" after being presented with an ad, especially in the 25- to 34-year-old cohort
- "Conversion": Action taken after encountering an ad; indicative of a user/potential consumer interacting with an ad (measure of the cost-effectiveness of the ad)
- When a user/potential consumer adds an item to their shopping cart upon arrival to the website, then they are "converted"
- Relatively higher propensity of women for conversion as compared to men
- Women are more expensive to advertise to in social media
- Since the algorithm used to deliver the ad for STEM careers was not developed so as to take into account the above imbalance between women and men, the ad was unintentionally shown to more men than women
- A lump sum invested in an ad may end up reaching more men than women (displayed more on male profiles than female profiles)
- "Impressions": Number of times an ad has been displayed on social media, i.e., frequency of delivery
- Clicks more for female Facebook users
- Gender differences and unintended discrimination are detected in the delivery of social media ads for STEM careers

# The digital sector (Artificial Intelligence and cybersecurity)

- The gender gap between females and males continues to exist across all digital technology domains, with Artificial Intelligence and cybersecurity being among the domains with the largest gaps
- The average percentages of females in AI and cybersecurity, worldwide, are 12% and 20%, respectively
- Both the Artificial Intelligence and cybersecurity domains still carry stereotypes and underlying gender biases; there are also personal and societal barriers that affect the selection of a career in these domains
- The efforts made to achieve gender parity in the digital sector are of short-range, since they have been applied with a very small sample and only in certain countries

# Main discussion points

**1. Determinants of the gender gap**

- Biological, individual (psychological), and socio-cultural determinants of the gender gap
- Primacy of socio-cultural factors over biological factors or factors at the individual level of reference
- As long as the socio-cultural context does not change to favor gender equality in STEM, any change at the individual level will not be sustained in the long run

**2. No magic wand to fix the gender gap**

- Interventions targeting individual participants may backfire (increasing awareness of bias is correlated to increasing self-reported social identity threat for female respondents)
- Interventions (workshops) need to be delivered within real-world contexts (not staged; take over the ownership of the process)
- Different STEM fields may need to be treated differently (e.g., biological sciences and chemistry: from formal education to entering workforce)

# Main discussion points

**3. Problematize the "leaky pipeline" metaphor**

- Critical readings of the "leaky pipeline" metaphor and its assumptions for linearity and unidirectionality in career trajectories criticize

  (1) the normative paradigm of a supposedly deterministic series of subsequent stages that women have to follow;

  (2) its overt focus in the supply-side (i.e., what is currently offered within a masculine culture), and not the demand-side (i.e., women's needs and desires), ;

  (3) the "normalization" of the male condition, according to which the female condition is to be measured and judged

**4. Create enabling environments in education and workplace**

- Creating enabling environments without compromising free choice
- Remove the barriers skewing female interests, preferences, and choices (gender stereotypes and gender discrimination)
- Complexity: Overlap of optimal childbearing years with the most productive years in a female's career path); female agency in making decisions
- Incentive structures

# Main discussion points

## 5. Problematize the role of schools

- The focus in primary schools should be to examine any gender gaps emerging at the start of formal schooling
- A suggestion is to provide role models to students through networking with academic and other partners in local ecosystems and hubs
- The current prevailing exam-oriented culture pushes back decisive choices of STEM subjects to lower secondary education

## 6. Multi-level approach needed to address the gender gap

- Micro-level, referring to changes in instruction, student-teacher interaction and peer interaction in schools
- Meso-level, with educational institutions changing themselves to provide enabling environment's for female students, and targeting positive feedback loops leading to bottleneck effects
- 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

**1. Stakeholder interaction at the EU level (macro-level)**

- Devise and update a toolkit for addressing gender disparities
- The toolkit can be adopted by institutions in administration (e.g., Ministries of Education), education (e.g., schools) and the workforce (e.g., industry)
- European Platform for Gender Equality in STEM, ICT, and CS
- Exploit decision-making heuristics and methods, such as the SWOT Analysis, as well as participatory scenario development

**2. Select and analyse cohort data anchored in real-world contexts (macro-level)**

- Tracking of real-life trajectories through educational levels to career choices and then to employment paths
- Challenges met and decisions made in transitions between one educational or career stage and the next
- Formalize and align record-keeping by stakeholders so as to allow for data collection and analysis in a natural manner, as part of their regular record-keeping, monitoring and evaluation procedures
- European Platform (multi-stakeholder networks; balance between vertical and horizontal approaches)

# Positive feedback loops/bottleneck effects for female interest or representation (meso-level)

| Educational level/workplace | Positive feedback loops/bottleneck effects |
|---|---|
| **Primary education** | ○ Female students, already not interested in the educational material they still need to work with, may be further marginalized and discouraged in peer interactions and collaborative work by being trusted less than their male peers.<br>○ Inconsistency between STEM attitudes/grades and STEM career beliefs for girls, which marks the transition from primary to secondary school, seems to be crucial for consolidating the mindset of female students with regard to field-specific ability beliefs. |
| **Secondary education** | ○ Fewer numbers of female students interested in STEM careers lead to females being deprived of social belongingness in STEM, which further holds back female STEM interest. |
| **Higher education** | ○ Solidarity among female academics and researchers may be jeopardized if a certain segment of the female population chooses the path of responsibilisation and another disregards or undervalues this same path.<br>○ Female students are less likely to persist in initial STEM majors when the introductory STEM course is taught by a female instructor, since female students tend to receive lower grades in courses taught by female instructors. |
| **Workplace** | ○ The declining percentage of females at higher positions has an adverse effect on female recruitment, which decreases further the odds of females being appointed to higher positions.<br>○ The social media ad market prizes female “eyeballs” due to increased likelihood of conversion, which results in a lump sum invested in an ad reaching more men than women. |

# Policy recommendations

**5. Problematize reference material and pedagogical approaches (micro-level)**

- Identify existing gender bias and gender stereotypes in content and reference material, as well as in teacher-student interactions, which may hinder gender equality
- Inquiry-based learning in STE(A)M as an arrangement for learning and instruction

**6. Problematize peer interactions (micro-level)**

- Jigsaw approach: students switching from an initial peer group, to which they are assigned in order to accomplish a main task (home group), to an expert peer group, where students specialize in learning to perform specific sub-tasks and back to the home group
- Peer assessment: Peer assessor and peer assessee roles (reciprocal peer assessment arrangement)
- Catalyse desirable effects of collaborative learning

# Draft scenarios for joint stakeholder action to promote gender equality (participatory scenario development): Focus schools, secondary education

| | Business-as-usual | Small-effort | Best-case |
|---|---|---|---|
| **Peer interaction (micro-level)** | Indifference or competition among peers prevailing and setting the agenda | Peers interacting in collaborative learning arrangements with rotation of roles | Interaction between peers capable of self-regulating their learning trajectories |
| **Instruction (micro-level)** | Existing curriculum and exam-oriented instruction not questioned | Transition from existing lesson plans to gender-informed pedagogical approaches | Instruction establishing and maintaining bridges with actors external to the school |
| **Student-teacher interaction (micro-level)** | Determined by authority and power-differentials between teachers and students | Determined by rapport; teachers in a facilitator role for scaffolding student learning | Teachers inspiring and empowering students as female and male role models |
| **School's culture (meso-level)** | Masculine; contaminated by salient and latent gender stereotypes and biases | Problematized, in transition; dominant stereotypes and biases challenged | Emancipatory and enabling for both female and male students and teachers |
| **School's role (meso-level)** | Implementer; innovation inhibited/avoided due to constraints, which cannot be overcome | Stakeholder-networked in local ecosystems; constraints addressed by external input | Innovator; using constraints to reconsider and revise existing practices |
| **School's contribution to reform (macro-level)** | Top-down policy adapted to local circumstances and implemented with confined flexibility | Using toolkit to launch initiatives at the individual learner and institutional level | Reflecting upon practice to renew the toolkit in regular communication with other stakeholders |