

GENDER STEREOTYPES IN EDUCATION: HIDDEN MECHANISMS AND THEIR IMPACT ON ATTITUDES TOWARD STEM

Agata Lada, & Anna Stefanowicz-Kocol

Department of Chemistry, University of Applied Sciences in Tarnow/A (Poland)

Abstract

Despite the growing number of initiatives promoting equality in education, entrenched gender stereotypes continue to influence students' educational choices. Girls in particular often internalize beliefs about their alleged lack of aptitude for science and technology, which undermines their self-confidence and limits their participation in STEM subjects (science, technology, engineering, mathematics). The aim of this project is to identify and analyze gender stereotypes operating within the school environment and to assess their impact on girls' self-assessed competencies, motivation, and educational decisions. The study also seeks to highlight effective teaching strategies and support tools that may help neutralize these stereotypes. A mixed-methods approach was employed. The quantitative component involved a survey of secondary school students, measuring self-perceived abilities in science, attitudes toward gender roles, and declared educational choices. The qualitative component included focus group interviews with female students and teachers, exploring experiences related to gender equality and academic support. The data were analyzed using statistical and thematic methods. The findings indicate that gender stereotypes continue to significantly affect how girls perceive their scientific abilities. Protective factors include exposure to female role models and educational environments that promote equality and collaboration. The results may serve as a foundation for developing pedagogical recommendations and support programs aimed at empowering girls in STEM, as well as for informing educational policies focused on reducing gender disparities.

Keywords: *Gender stereotypes, STEM, educational equality.*

1. Introduction

Despite sustained international efforts to promote gender equality in education, significant gender disparities persist in science, technology, engineering, and mathematics (STEM), particularly in mathematics-intensive and technical fields such as physics, engineering, and information technology. These disparities remain notable despite the convergence of overall academic achievement between girls and boys across many countries (Else-Quest et al., 2013; Mann et al., 2015), suggesting that differences in ability alone cannot explain gendered participation patterns. Instead, socio-cultural and institutional factors appear to shape students' motivations, attitudes, and educational aspirations.

Secondary education represents a critical developmental period during which students form academic self-concepts and make decisions influencing future career trajectories. Research shows that gender gaps in STEM attitudes and intentions widen during this stage even when achievement differences are controlled (Legewie & DiPrete, 2014; Salmela-Aro et al., 2020). These differences are linked less to performance decline than to gendered shifts in self-efficacy, interest, and perceived belonging within STEM domains.

Gender stereotypes play a central role in shaping these trajectories. Stereotypical beliefs about who is "naturally suited" for STEM are embedded not only in explicit attitudes but also in everyday practices, teacher expectations, peer interactions, and broader cultural narratives (Makarova et al., 2019; Raabe et al., 2019). As a result, girls may internalize lower confidence and weaker identification with STEM despite comparable performance levels. Cross-national research further reveals the "gender-equality paradox," whereby stereotypes associating mathematics with men can be stronger in economically developed and gender-egalitarian societies, highlighting the role of cultural mechanisms in shaping educational choices (Breda et al., 2020).

The present paper synthesizes empirical research on gender stereotypes in education to examine hidden mechanisms of stereotype transmission and their impact on STEM-related attitudes, including self-efficacy, interest, and career aspirations.

2. Theoretical framework

Gender stereotypes in STEM can be conceptualized as multidimensional constructs encompassing beliefs about ability, identity, and occupational suitability. Research identifies three primary dimensions: ability-based stereotypes, career-oriented stereotypes, and subject-specific stereotypes (Makarova et al., 2019; Tellhed et al., 2023). Ability stereotypes portray boys as naturally more suited to mathematics and technical reasoning, while career stereotypes frame STEM professions as masculine domains. Subject-specific stereotypes further create hierarchies within STEM, with mathematics and physics most strongly associated with masculinity (Raabe et al., 2019; Breda et al., 2020).

These stereotypes function as socially shared belief systems embedded in institutional practices. From a sociological perspective, they act as symbolic boundaries signaling who belongs in particular academic fields (Legewie & DiPrete, 2014), while from a social-cognitive perspective they shape students' interpretations of feedback and social comparison, influencing motivation and self-concept (Chan, 2022). Notably, girls often perceive STEM as a uniformly masculine domain, whereas boys differentiate between subjects, which has implications for intervention design.

Peer dynamics represent a key mechanism of stereotype reproduction, as students align interests with perceived gender norms to maintain social acceptance (Raabe et al., 2019). The presence of female peers interested in STEM can function as a protective factor by validating non-stereotypical identities, whereas male-dominated environments may reinforce perceptions of non-belonging. Teachers also play a dual role as both transmitters and potential disruptors of stereotypes. Teacher expectations and implicit biases influence feedback and instructional practices (Makarova & Herzog, 2015), while exposure to female teachers can increase girls' engagement with advanced STEM pathways (Lim & Meer, 2017), though effects vary depending on context (Riegle-Crumb et al., 2017).

Family influences further shape gendered trajectories through differential encouragement and parental beliefs about ability and career suitability (Fernández García et al., 2019; Blažev et al., 2021). Together, these multi-level mechanisms contribute to cumulative socialization processes that sustain gendered participation patterns. Cross-national findings indicate that stronger gender stereotypes may coexist with higher levels of structural equality, suggesting that cultural narratives and identity processes play a crucial role in maintaining gender segregation in STEM (Breda et al., 2020).

3. Research objectives

The aim of the empirical part of the study was to determine how perceived and internalized gender stereotypes influence attitudes toward STEM among female students at educational stages associated with the formation of academic decisions. Particular attention was devoted to three interrelated constructs: (1) STEM self-efficacy, (2) sense of belonging within the STEM domain, and (3) declared educational intentions. An additional objective was to identify hidden mechanisms of stereotype transmission through the analysis of participants' experiences as well as their recommendations regarding institutional actions aimed at reducing stereotyping.

4. Methodology

The study employed a mixed-methods design, combining a quantitative component (an online survey) with a qualitative analysis of open-ended responses.

The study sample consisted of $N = 79$ participants. Participants' ages ranged from 16 to 20 years, with a clear concentration between 17 and 19 years of age. The educational profile of participants was diverse; however, the medical field predominated (58.2%), indicating that a substantial portion of the sample was situated within STEM-related disciplines.

A set of five-point Likert scales was employed, including:

- STEM Intentions (SI),
- Internalized Stereotypes / Belonging Threat (IST),
- Female Role Model Exposure (FRM),
- STEM Self-Efficacy (SSE),
- Equity-Oriented Classroom Climate (ECC),
- Perceived Gender Stereotypes (PGS).

Additionally, focus group interviews were conducted with female students and teachers, aimed at exploring experiences related to gender equality and academic support. Quantitative data were analyzed at the level of response distributions and interpretative trends between psychological constructs. Qualitative data were subjected to thematic analysis to identify dominant narrative patterns.

5. Results

Response distributions in the STEM Intentions (SI) module indicate substantial heterogeneity in participants' declarations: while some respondents are considering or planning STEM-related educational pathways, a parallel group remains uncertain or distanced from such plans. These findings are consistent with the sample profile (strong representation of medical and science-related fields) as well as the reported level of engagement with STEM subjects (approximately 73% indicating "yes" or "partially").

In the STEM Self-Efficacy (SSE) module, responses more frequently reflected moderately high confidence in one's abilities to perform STEM-related tasks ("rather agree" and "strongly agree"). At the same time, a significant proportion of neutral responses emerged in items referring to coping with novel, demanding, or evaluative situations. This pattern suggests a profile in which general competence confidence coexists with sensitivity to evaluative contexts and social comparison processes, consistent with literature on belonging threat mechanisms and the stereotypical coding of STEM domains.

In the Perceived Gender Stereotypes in STEM (PGS) module, responses predominantly indicate that participants recognize the presence of gender stereotypes within educational and broader social environments, including media representations. The Internalized Stereotypes/Belonging Threat (IST) module suggests that a subset of respondents experiences elements of belonging threat (e.g., doubts about "fitting" into STEM domains). At the same time, several items elicited a higher proportion of neutral responses, which may reflect heterogeneity of experiences, including differences across schools or universities, group compositions, and varying exposure to stereotypical comments or discriminatory practices.

In the Female Role Model Exposure (FRM) module, there is simultaneous evidence of (1) high declared awareness and recognition of women present in STEM fields and (2) signals suggesting that their visibility within educational and symbolic spaces is perceived as insufficient. Quantitative findings are consistent with open-ended responses, in which contact with female teachers/lecturers or well-known figures was described as a factor enhancing motivation, normalizing a sense of belonging, and reducing feelings of being "out of place."

Response distributions in the Equity-Oriented Classroom Climate (ECC) module suggest that a substantial proportion of participants perceive their educational environment as relatively supportive of equality (at least in certain aspects). However, responses are not homogeneous, and some items reveal clear signals of tension related to differences in gender-based treatment. This pattern is directly reflected in the qualitative materials (see Section 5.5).

The thematic analysis of open-ended responses identified five dominant areas:

- Unequal expectations and distribution of opportunities in the classroom (teacher expectation bias): respondents described, among others, more frequent selection of boys for challenging tasks, answering questions, and participation in competitions, as well as the relative downplaying of girls' achievements; references were also made to a form of "leniency" toward boys combined with attributing greater "talent" to them.
- Stereotypical comments and microaggressions as mechanisms of everyday norm reproduction: participants reported situations in which girls were told they were "weaker in mathematics," that technical education paths were "for boys," or experienced comments from peers or teachers that questioned their competence.
- Social pressure, fear of evaluation, and mechanisms of continuous comparison: responses concerning girls' withdrawal from STEM frequently highlighted low self-confidence, fear of making mistakes, social pressure, and concerns about being the only woman in a group, which was associated with discomfort and heightened scrutiny.
- Role models as a protective but conditional factor: contact with women in STEM was often described as strengthening motivation and agency ("it showed me that I also have a chance"); however, some responses suggested that the mere presence of women is insufficient if the environment remains a "chilly climate" or if teachers do not actively support engagement.
- Institutional recommendations: from symbolic representation to procedural change: proposed actions included consistent responses to stereotypical comments, clear anti-discrimination procedures, anonymous assessment practices, changes in language and teaching materials, increased visibility of women in STEM (media, schools, lectures), and meetings with women working in STEM professions; many responses emphasized the importance of practicing equal treatment rather than relying solely on formal declarations.

6. Discussion

Empirical findings support the theoretical framework presented in Section 2, indicating the multi-level operation of gender stereotypes within school environments. First, quantitative data suggest the coexistence of moderately high STEM self-efficacy alongside a simultaneous recognition of stereotypes in the surrounding environment. This profile is consistent with literature showing that the key domain of inequality may not lie solely in competence itself, but rather in how competence is interpreted within the context of gender norms, social comparison, and signals of belonging.

Second, qualitative data reveal “hidden” mechanisms (hidden curriculum) manifested through routine instructional practices (e.g., who is selected for tasks, how teacher attention is distributed, to whom “talent” is attributed), as well as peer-driven mechanisms reinforcing gender norms. Narratives describing social pressure, fear of evaluation, and being the “only girl” in a group align with the concept of belonging threat, which—consistent with the proposed framework—may weaken STEM intentions and persistence regardless of actual performance levels.

Third, the convergence of FRM results and open-ended responses indicates that exposure to female role models functions as a protective factor; however, its effectiveness depends on how it is embedded within the institutional environment. While role models may help “normalize” a sense of belonging, they cannot substitute for formal procedures addressing stereotyping nor compensate for the systematic lowering of expectations toward girls.

7. Conclusions

The collected data indicate that gender stereotypes remain a significant component of STEM-related educational experiences, operating primarily through psychosocial mechanisms such as sense of belonging, fear of evaluation, and the interpretation of difficulties as evidence of a lack of aptitude. The findings suggest that the key domain of inequality lies not solely in differences in competence, but in how competence is interpreted within the context of social norms, signals of belonging, and everyday educational practices. At the same time, protective factors were identified, particularly exposure to female role models and educational environments that support equality and collaboration, which may strengthen girls’ motivation and identification with STEM.

Participants’ recommendations highlight the need to combine symbolic actions, such as increasing the visibility of women in STEM and using inclusive language and teaching materials, with procedural measures including consistent responses to stereotyping, the implementation of clear anti-discrimination standards, and the equitable distribution of tasks and developmental opportunities. This suggests that effective interventions require a systemic approach aimed at disrupting stereotype transmission mechanisms at the level of classroom interactions and institutional structures, rather than solely strengthening individual motivation among female students.

From an educational policy perspective, the study findings point to the need to move beyond strategies focused primarily on increasing access to STEM toward approaches that address the psychosocial determinants of girls’ educational choices. This includes developing teachers’ competencies in stereotype-sensitive pedagogy, implementing equity-oriented standards in assessment and classroom organization, and establishing long-term programs that enhance the visibility of women in STEM as a means of normalizing a sense of belonging.

The integration of quantitative and qualitative data in this study demonstrates that gender stereotypes in STEM function primarily as a system of hidden social signals shaping individuals’ interpretations of their own competence and educational decisions. Consequently, reducing gender inequalities in STEM requires simultaneous interventions at the level of individual beliefs, social dynamics, and structural educational conditions. This represents a key direction for future research as well as for the development of pedagogical practices and educational policies aimed at strengthening girls’ participation in STEM.

References

- Blažev, M. (2021). *Učinak vlastitih i roditeljskih rodno stereotipnih uvjerenja na motivaciju učenika u STEM području*. University of Zagreb.
- Breda, T., Jouini, E., Napp, C., & Thébaud, G. (2020). Gender stereotypes can explain the gender-equality paradox. *Proceedings of the National Academy of Sciences*, 117(49), 31063–31069. <https://doi.org/10.1073/pnas.2008704117>
- Chan, R. (2022). A social cognitive perspective on gender disparities in self-efficacy, interest, and aspirations in STEM. *International Journal of STEM Education*, 9(1), 1–15.
- Else-Quest, N. M., Mineo, C. C., & Higgins, A. (2013). Math and science attitudes and achievement at the intersection of gender and ethnicity. *Psychology of Women Quarterly*, 37(3), 293–309.
- Fernández García, C. M., Torío-López, S., García-Pérez, O., & Inda-Caro, M. (2019). Parental support, self-efficacy beliefs, outcome expectations and interests in STEM. *Universitas Psychologica*, 18(3), 1–14.
- Legewie, J., & DiPrete, T. A. (2014). The high school environment and the gender gap in science and engineering. *Sociology of Education*, 87(4), 259–280.
- Lim, J., & Meer, J. (2017). Persistent effects of teacher–student gender matches. *Journal of Human Resources*, 52(3), 1–36.
- Makarova, E., Aeschlimann, B., & Herzog, W. (2019). The gender gap in STEM fields: The impact of gender stereotypes on secondary students' career aspirations. *Frontiers in Education*, 4, 60.
- Raabe, I. J., Boda, Z., & Stadtfeld, C. (2019). The social pipeline: How friend influence and peer exposure widen the STEM gender gap. *Sociology of Education*, 92(2), 105–123.
- Riegle-Crumb, C., Moore, C., & Buontempo, J. (2017). Shifting STEM stereotypes? Considering the role of peer and teacher gender. *Journal of Research on Adolescence*, 27(3), 492–505.
- Salmela-Aro, K., et al. (2020). The role of motivation and academic well-being in STEM transitions. *European Journal of Psychology of Education*, 35, 321–348.
- Tellhed, U., Björklund, F., & Strand, K. K. (2023). Tech-savvy men and caring women: Middle school students' gender stereotypes predict interest in tech education. *Sex Roles*, 88, 1–15.