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How to Address Stereotypes and Practices Limiting Access to STEM-Related Education for Women and Girls

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Patterns of women's representation in STEM

In most western countries women are highly underrepresented in those Science, Technology, Engineering, and Mathematics (STEM) fields that have not a direct connection with the provision of care, such as engineering and computer science (UNESCO, 2021). However, women are highly represented in those STEM fields associated with health and the provision of care, such as medicine, chemistry, or biology. Interestingly, current research has identified a **paradox** between levels of gender equality and the participation of women in STEM fields (Stoet and Geri, 2018). In this way, the more egalitarian the countries are (for example, Norway or Finland), the less female participation in STEM fields. However, countries with less advanced policies in terms of equality (such as India) presented better levels of female presence in STEM fields. Similarly, a more recent study by UNESCO (2019) corroborates the existence of this paradox in the participation of women in studies related to Information and Communication Technologies (ICTs). In countries such as Norway, Sweden, Finland and New Zealand (located respectively in positions 2nd, 3rd, 4th and 7th in the global gender equality index, that is, with high rates of gender equality) the percentage of female participation in ICT studies does not reach 30%. 15.97% in Norway, 28.17% in Sweden, 20.64% in Finland, and 24.38% in New Zealand). However, countries with low rates in terms of gender equality such as Tunisia (54.47%, 119th place), United Arab Emirates (57.78%, 121st place), Algeria (54.28%, 128th place), Bahrain (50.86%, 132nd place), Syria (57.31%, 146th place), Qatar (46.58%, 127th place), India (46.34%, position 108) or Morocco (45.01%, position 137) have rates of women participation in ICT studies comparable to those of men. Spain is ranked 29 of the global index of equality, but only 14.02% of the people enrolled in ICT studies are women.

This data prove that in the countries with the lowest scores of gender equality, pressures for achieving good working conditions and quality of life encourage the participation of girls and women in STEM fields. A study conducted at the end of the first decade of the 2000s across 44 countries analyzed gender segregation in the choice of studies (see Breda et al., 2020) and suggested that this paradox was due to the fact that the countries with the highest **rates of gender equality** were also the most developed where people tend to use self-expressive value systems of their decisions in terms of motivation and interest. However, in countries with lower equality rates, women justify their choice of STEM studies in terms of economic autonomy, that is, these type of STEM fields will allow them to produce sufficient resources for their own sustenance and that of their families (Sáinz et al., 2020a).

The afore-mentioned pattern of underrepresentation in STEM has several **implications**, which have a negative effect on equal opportunities between men and women. If the number of women and men in some STEM studies and professions is not equal, there is a risk that technological products and services do not represent the needs and demands of women. On the one hand, this phenomenon implies that few women develop interest in male-dominated STEM fields. Similarly, as there is dearth of female role models in associated educational (i.e. few technology teachers are women) and professional contexts (i.e. few technology developers are women) when making academic and career decisions young women do not find inspiration in women who have contributed to the scientific and technological innovations and achievements in these fields. In addition, when accessing to the labor market women also lack of female role models and mentoring figures who could guide and accompany them throughout their professional development. In a similar vein, women have less opportunities than their male counterparts to expand their networks of influence.

On the other hand, there is a tendency to make invisible the **contributions of women** in scientific and technological fields whereas, on the contrary, highlight the contributions of men in these areas. This undoubtedly has an impact on the way in which these contributions are transmitted and taught in the school and university contexts, but it also has an influence on the workplace, where in many occasions, the contributions of women to the development of a discipline, an idea, or a specific project tend to be undervalued. Likewise, in many societies male-dominated STEM

fields are associated with prestige in educational and professional terms, since STEM subjects are considered as the most difficult subjects to achieve at school, whereas STEM professions tend to be connected with well-paid jobs and leadership (UNESCO, 2019). In the opposite direction, studies and careers highly dominated by women tend to have less social prestige (in terms of social position, leadership, and access to positions of power or salary) than male-dominated studies and careers.

Factors shaping women's underrepresentation in STEM

The underrepresentation of women in STEM pathways is a **complex phenomenon**, influenced by several factors at the personal (including cognitive characteristics such as academic ability and achievement, background characteristics such as gender and socioeconomic status, or affective characteristics, such as self-efficacy, motivation, belonging, and engagement), environmental (such as stereotypical cultural and societal beliefs about gender and STEM, or the lack of female role models in STEM), and school level school level (such as educational policies, school climate, teachers' beliefs and attitudes, or pedagogy) (Sáinz et al., 2022; Van der Hurk et al., 2019; UNESCO, 2017).

Current **societal stereotypes** about the type of person who is expected to succeed in STEM career pathways (e.g., middle-class white males) discourage many young people who do not meet these attributes (e.g., girls, students from low SES or migrant families, as well as non-white students or students with disabilities) from entering in STEM fields (Rosenzweig and Wigfield, 2016; Sáinz and Müller, 2018; Sáinz et al., 2022). Strikingly, there exists the belief that women are more competent in reading and languages, whereas men are more competent in math, science, and technology. This implies that the adolescents themselves, boys or girls, assume these social beliefs in such a way that they end up making these beliefs a reality. Thus, since women are not expected to perform well in STEM fields requesting high scientific and technological talent, girls avoid enrolling in these fields. And, similarly, since boys are expected to have lower talent in languages than their female peers, many do not consider careers demanding high linguistic skills as a suitable option for their future (Sáinz et al., 2017).

In addition, recent studies have corroborated the assumption that women are more likely than men to be underrepresented in many STEM fields because women are stereotyped as being less likely to possess a sort of **'raw' talent** than men (Meyer et al., 2015). There is a widely held belief that STEM degrees and careers are difficult (and therefore adhered more academic prestige than other non-STEM fields) and that a student needs to be brilliant to enter and succeed in these fields (Shin et al., 2016). These gender differences in perception of intellectual ability emerge at an early age (Bian et al., 2017). But, there is lack of longitudinal research informing about how these beliefs develop over time and how these beliefs vary or not across cultures.

Research on young people's portrayal of a **typical person working in STEM** also shows that young people's portrayals of STEM professionals include different features that make reference to the person's physical appearance (white, middle-aged or elderly, wearing glasses or a lab coat in the case of people in science, untidy and casually dressed in the case of people in computer sciences, or wearing a tie in the case of people in engineering) and other personal features related to their personality (Cheryan et al., 2013; Sáinz et al., 2019). These personality-related features include several characteristics such as their intellectual capacity (intelligence), their personal preferences (type of music, readings, or sports) and disposition to behave in a given way (normally they are perceived as geeks, freaks, lacking social skills, and without interest in social contact). Moreover, several studies show that male-dominated jobs such as engineering and other technology-related occupations are associated with a high status and well-paying stereotype (Sáinz et al., 2016). In addition, innovation and technological change have been traditionally associated with masculinity and the development of masculine roles.

Young people make **decisions about what to study and what to work** on based on preconceived ideas or stereotypes about the kind of people who work in a certain field and about the type of work that these people carry out. In addition, many young people choose a career that reflects their personality and, therefore, gather ideas about the prototypical characteristics (in terms of appearance and personality traits) of the person who works in a particular field. Information about a particular course or career will not even be sought by young people if they have no affinity with the associated stereotypes. All these stereotypes about people in STEM do not facilitate women's sense of belonging and the belief that they 'fit in' those STEM fields and also affect the academic and professional decisions of many young people who also feel that they are not 'welcome' in these fields because their characteristics do not 'fit in' the expectations about the ideal type of person studying or working in these fields. Being able to identify themselves in a future role is the key influencing factor of young people's academic and career decisions. Consequently, if young women do not identify with the features of that ideal person studying or working in STEM they will not choose those STEM academic and career pathways.

Gender socialization also exerts an enormous influence on the choices that young people do, as well as what they consider important and a priority in their lives, whether they are men or women (Eccles, 2007). During school hours many teachers tend to endorse cultural gender stereotypes to their students' achievement—for example, the belief that boys have higher math and scientific abilities than girls, girls are better at languages (Eccles, 2007). On the one hand, these perceptions influence teachers' decisions regarding achievement levels (Riley, 2014). In addition, teachers' attributions of their students' academic success or failure not only shape the way they perceive and behave toward their students, but also influence how students perceive their own potential, their motivation toward school, and their attitudes toward learning.

Messages transmitted by **teachers** in the classroom through language and other didactic resources, along with textbooks tend to portray men and women in traditional occupational roles and encourage gender stereotypes (López-Navajas, 2015; Warren et al., 2019). Educational practices delivered through textbooks, teachers, and further educational instruments (classroom dynamics such as the delivery of work among students, the type of instruction) that provide teaching beyond existing curriculum (known as *hidden curriculum*) and gender bias in learning materials promote gender differences in school achievement (Sáinz et al., 2021).

Moreover, teachers' **gender-stereotyped beliefs** about girls' and boys' aptitudes explain gender differences in students' competence beliefs, values, and achievement-related behavior (Eccles, 2015). Meanwhile, these influences may lead boys to excel in stereotypically masculine domains, such as math, science, and sports and girls to excel in stereotypically feminine domains such as language (Leaper & Brown, 2014). Secondary school teachers' perceptions and beliefs regarding studies and occupations as well as students' academic abilities play a crucial role in the final choices that students make (Sáinz et al., 2012). Consequently, boys and girls tend to pursue studies and occupations congruent with those stereotypical domains.

Similarly, **parents** seem to also endorse the belief that boys and girls have different competences in STEM subjects. They shape their children's perception of their ability, thus influencing the choices they make, by providing dissimilar messages about their ability in different domains (Eccles, 2007). Parents play an important role in influencing a child's opinion on whether they 'fit in' STEM. This reinforces the importance of breaking perceived stereotypes amongst this group. However, there is a lack of research looking at how parents from different backgrounds cope with these stereotypical believes throughout their children's life-course, especially when young people make decisions on the kind of academic and/or career pathway they would like to follow.

Many parents also tend to endorse these stereotypical portrayals and influence their children's decisions to pursue different pathways. Several **parents and teachers** draw on gender stereotypes regarding boys' and girls' abilities, and they communicate these beliefs through various indirect

and explicit behaviors (Eccles, 2007). Girls are therefore considered to be better at English than boys, whereas boys are considered to be better at math and other STEM domains (Sáinz & Eccles, 2012). In addition, girls are thought to work harder to master math and other STEM subjects than boys, and vice versa for languages.

Similarly, the **structure of the educational system** also favors that students who choose a particular academic pathway may have more stereotypical views of the competences that men and women have in STEM subjects. For instance, research in Spain proved that boys on science and technology tracks believed that boys have greater abilities in STEM, while girls on social sciences and humanities pathways are more likely to hold sexist beliefs about boys performing better in these STEM subjects (Sáinz & Gallego, 2022). However, further research in other societies that corroborates this tendency is required.

During adolescence, **peer groups** have an enormous influence on the final choices that young people make. Sexist attitudes (especially among peers) may lead girls to feel less competent in tasks non-congruent with feminine roles in STEM disciplines and to underperform in related contexts. For instance, a study with Spanish secondary students revealed that students on the science pathway were more likely to believe that boys perform better in math, physical science and technology, and that girls perform better in literature, biology and languages. Boys and girls in gender-congruent pathways were more likely to consider boys to have greater abilities in math, physical science and technology, whereas girls in languages, biology and literature (Sáinz & Gallego, 2022). Interestingly, these results illustrate how gender identification with traditional roles become particularly salient among boys and girls enrolled in gender-congruent academic tracks. However, more research is needed about this issue in other contexts.

Finally, the different **mass media, social networks, and videogames** contribute, through advertising, the use of images, and other communication strategies, to reinforce stereotypes and preconceived images of ideal characteristics that people who occupy certain professions must have, as well as about the gender roles normally attributed to men and women (Sáinz et al., 2017). Studies on the influence of mass media in breaking stereotypes about STEM professions are required.

Recommendations

In the following pages some recommendations for policies to be implemented at the international, national, regional, and local level are commented. To respond to such a complex problem, the involvement of different socializing agents (families, teachers, media, business, technology developers, administrations, etc.) and the global society is critical. Their join efforts may contribute at reducing gender gaps in the choice of studies and professions.

It must be recognized that not all women are discouraged by existing gender stereotypes regarding the characteristics and skills required to enter and develop in technological fields (Sáinz et al., 2020). In fact, those women with higher levels of self-efficacy or self-confidence in mathematics or science will have better performance in these fields, as they will be more likely to choose STEM studies and professions to a greater extent than girls with low levels of self-efficacy and confidence in STEM. Similarly, many women are not discouraged with the belief that they do not meet the **stereotype or prototype** of cold, antisocial and strange person who works in these fields. Grippingly and contrary to their male counterparts (who identified with the prototypical person in STEM) young women who have already chosen a STEM career do not identify with that image (Sáinz et al., 2020a).

Ideally, **interventions and initiatives** addressing gender stereotypes about STEM professions should be designed to address potential changes in malleable personal factors (i.e. skills, attitudes, choices, self-perceptions, or interest) by trying to simultaneously modify different aspects at the

social (i.e. stereotypes about STEM fields, or lack of female role models), environmental (i.e. parents, industry), and at the school level (i.e. pedagogies, career guidance practices) (Sáinz et al., 2022). One of the weaknesses of the programs and projects addressing stereotypes and practices limiting access to STEM-related education for women and girls is that they put the focus only on girls and not on the broader environment and the people in it (Sáinz et al., 2021). This could be counterproductive since this seems to put the 'blame' and responsibility for change on girls and women. This also suggests the need to work with boys because it is necessary that they also change their mindset and actively contribute to breaking down gender stereotypes (Sáinz et al, 2020). They should take into account contextual factors intrinsic to the educational environment (mainly socioeconomic and sociocultural origins of families and schools) to promote effective changes.

Engaging parents from different backgrounds with children in possession of different personal and social characteristics is required. More interventions addressed to secondary school students, and particularly to parents with low educational attainments, should be implemented in order to promote that they develop **positive coping strategies against academic sexism** (Sáinz et al., 2020b). In addition, secondary teachers should also receive specific training on how to avoid and combat sexist beliefs regarding boys' and girls' academic competence. All these training sessions should incorporate the voices of women in STEM professions, so that they can exchange their experiences with younger girls regarding how they managed to overcome difficulties, such as for instance, the discouraging comments made by significant people about their lack of competence in STEM.

It would be crucial that parents and the whole educational formal and informal system are targeted when fighting gender stereotypes about people in STEM jobs. For this reason, families must understand that the fields of science and technology generate **multiple opportunities** for women, beyond traditional gender roles. It must be avoided, for this reason, that the different socializing agents emit contradictory messages in that sense. The behavior of parents must be aligned with the one of teachers' and vice versa, because it is useless to transmit messages based on equal opportunities between men and women at home if at school young people have experiences that show the opposite.

Schools should promote different interventions involving the whole educational community in order to avoid and reduce any sign of academic sexism. Initiatives to raise awareness among the educational community about the impact of sexist beliefs about girls' and boys' academic competence on students' career decisions would be crucial to fight against gender gaps in the choice of studies and professions. Schools might be effective at reducing academic sexism if they conducted a clear school policy against it and promoted specific teacher training on how to cope with sexist beliefs and situations in the school context (Sáinz et al., 20. These teachers should actively work with their students to encourage them how to deploy positive and active coping strategies against any type of sexist belief. Providing teachers with training on the incorporation of inclusive instruction dynamics would contribute to combat stereotypical behavior in the classroom in general and stereotypes about academic and professional pathways in particular.

Since there is a lack of recognition of the contributions of women to STEM fields and a dearth of female role models showing their outstanding contributions in the teaching of STEM content, teachers across the different stages of the educational system should be provided with resources and didactic materials that make visible the contributions of women to STEM. In addition, afterschool curricular STEM activities need to be developed to raise both boys' and girls' interest in STEM fields by making them more accessible and familiar. The optimal way to encourage young girls to pursue emerging high-growth roles, particularly those requiring STEM math skills, seems to expose them to the professional and personal experiences of actual female role models with a successful professional trajectory in STEM fields (Gonzalez et alt., 2020). For this purpose, inviting STEM professionals into schools to talk to students about the day-to-day work they carry could be a good strategy for this purpose. Also, taking girls and young people to STEM

workplaces is also crucial to make them aware of the tasks and activities STEM professionals develop in their working hours.

In addition, the **exposure to female role models** is highly recommendable when attempting to debunk stereotypical portrayals of people studying or working in STEM fields (González et al., 2020). However, a well-designed role model strategy should be deployed in order to increase its effectiveness among young people with potential in accessing to STEM careers. For this reason, in order to encourage female models to inspire scientific vocations for young girls, it is important not only to expose girls to outstanding women who have excelled in STEM careers, but also to present examples of women with whom they can easily identify because they have the same social and personal characteristics (for example, coming from similar geographical areas, belonging to the same cultural background or ethnical groups, etc.). In this regard, it would also be recommendable that not only girls, but also boys participate in these role model sessions tackling the historical underrepresentation of women in the different STEM fields (Sáinz, 2020). In a similar fashion, having more female teachers in STEM education may increase girls' interest in scientific and technological careers (Johnson et al., 2020), especially in those areas with a high underrepresentation of women, such as technology, computing, or physical science.

The promotion of **positive attitudes towards STEM** disciplines and subjects seems to be a worthy approach for debunking existing stereotypes about STEM fields, especially those highly male-dominated. However, more efforts must be deployed to raise awareness among stakeholders coming from the school and the industry about the importance of challenging negative statements about girls in STEM (i.e. their lack of competences in STEM subjects and professions) that could discourage girls from pursuing STEM activities and courses. In this regard, unconscious bias training programs targeting different stakeholders of the broader community (i.e. teachers, parents, and peer groups within and outside the school context, or human resources representatives) should be fostered by public policy.

Addressing **potential career opportunities associated with STEM fields** seems to be a good avenue for broadening girls' perspectives in the field. For this purpose, the promotion of initiatives incorporating career guidance activities and recommendations about study habits when learning STEM subjects would be recommendable. Academic and professional guidance programs (with a special attention to students in the last courses of secondary and higher education) need to incorporate a gender perspective and be more inclusive when attempting to combat gender gaps in STEM education. Since youth and girls from low socioeconomic backgrounds have less access and contact with science activities (Flecha et al., 2022) and are also less likely to receive encouragement from their parents to engage in STEM pathways (Sáinz & Müller, 2018), the intersection of gender with other factors of inequality (i.e. girls from rural areas, with migrant origins, or disabilities, etc.) have to be also incorporated in the design and evaluation of STEM interventions oriented to increase the interest of girls and young people from socially disadvantaged groups. It is equally important the development of measures that promote equality between men and women in the products and services offered by the different mass media, video games, and social networks, especially among those targeting young people.

Attempts to **change the way STEM subjects** (i.e. physical science or science) **are taught** in primary and secondary schools should be fostered with the organization for instance of prizes or funds that acknowledge and support these efforts. In this regard, the effect of including gender sensitive innovative pedagogies in the teaching of STEM activities could be compared with the effect pedagogies that do not include those gender innovative perspectives. In this regard, it would be necessary to implement a long-term strategy that contributes to change the way STEM subjects are taught in both formal and informal education. More initiatives are needed to analyze how the introduction of innovative pedagogies (such as project-based teaching or the introduction of core

subjects linked to computational thinking) can make technological STEM fields more attractive to young women.

One of the problems observed in the literature with the programs and interventions to promote the interest of girls in the fields of science and technology is that they deploy short-term actions which are not **sustainable over time** (Sáinz et al., 2022). Therefore, it would be ideal to examine whether intervention programs provide continuity over time and to analyze the evolution of girls' and young women's interest in STEM fields. The effectiveness of these programs and initiatives have to be evaluated in a more in-depth way. That is, the evaluation of the initiatives should be connected with the definite decisions that young people make about their future career pathways and have a focus on the long-term.

Expanding the **application** opportunities of the engagement activities to different contexts and disciplines **beyond STEM** would be also an ideal way to raise girls' interest in STEM by the enhancement of their social utility value (Rozenweig, Wigfield, & Eccles, 2021). In line with the United Nations 2030 Agenda for Sustainable Development, it would be recommendable that the initiatives aiming at combating gender stereotypes about STEM professions focus on topics that respond to current and future societal challenges (such as the fight against climate change, social injustice, or the use of Artificial Intelligence to benefit society). The promotion of interdisciplinarity and the application to different areas of knowledge beyond STEM could contribute to tackle the afore-mentioned societal challenges (Sáinz et al., 2020). This would be a good strategy to challenge current pre-conceptions about the lack of synergies between STEM and non-STEM disciplines.

It is thereby crucial that the initiatives and programs addressing gender stereotypes about STEM have an interdisciplinary perspective, incorporating researchers and teachers from the social sciences (mainly psychology, pedagogy, sociology, and educational sciences) and other fields of knowledge linked to pure sciences and engineering. In addition, a recent systematic review also reveals a shortage of interventions that incorporate the arts, humanities and social sciences into the fields of science and technology, best known in many instances as **STEAM** (Science, Technology, Engineering, Arts, and Mathematics). In this regard, the Spanish Ministry of Education has recently launched the STEM Alliance for female talent. This initiative aims at promoting STEAM vocations among girls and young people and reduce the gender gap. More than 100 companies and institutions participate.

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