

Women Missing in STEM Careers: A Critical Review through the Gender Lens

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Abstract: Although the number of female science students has increased at secondary level in many countries since 1990, this has not translated into pursuing a STEM education at tertiary level and not even into STEM jobs. It is thus important to analyze this issue of female participation in STEM disciplines, since their inclusion would empower them by improving the economy, health, and infrastructure worldwide and help to fight poverty internationally with technological and scientific interventions. This narrative review article aims to analyze the reasons behind female underrepresentation in STEM careers using the “feminist research methodological” approach. Underlying the conceptualization of gendering science, two specific concepts, gender role and empowerment, have been used. Here I have analyzed the educational, attitudinal, socio-cultural, and socio-economic aspects of why there are so few women in STEM careers. This analysis introduces some important concerns that can be focused on during policy implication to ensure gender equality in STEM careers. This article highlights the socialization process of young students (especially girls), who are expected to perform their stereotyped gender roles consciously or subconsciously both in the family and educational settings. These gendered ideologies are clearly interlinked to the career they become interested or influenced in. The analysis reflects and recommends that subject domains and job sectors should be gender neutral where life experiences and interests of individuals should be emphasized. Such important concerns raised in this article would help educators in policy implication to ensure gender equality in STEM careers.

Keywords: *Gender role, Science Careers, STEM, Girls’ empowerment*

Background and Problem

The lack of girls and young women pursuing a career in Science, Technology, Engineering, and Mathematics (STEM)¹ is a global problem. Even though the number of science students has increased at secondary level in many countries since 1990, this has not translated into pursuing a STEM education at tertiary level. At the international level, women in science remain something of a rarity (UNESCO, 2007). According to the UN Education, Scientific and Cultural Organization (UNESCO), less than 27% of

STEM researchers globally are women, including in developed countries like Australia, Canada, China and the UK. Among the developing countries, Lesotho and Cape Verde in Africa and Myanmar in Asia have almost achieved gender parity, but all other developing countries lag behind in including women in STEM disciplines. Unfortunately, there are 15% fewer women than men in STEM subjects in Japan, Bangladesh, India, Korea, and Nepal (TRIMUNC, 2015).

There are many educational, attitudinal, socio-cultural, and economic barriers to girls pursuing a

systematic analysis of higher STEM education and STEM career choices and uptake.

¹ In this article I specifically focus on the subject of “science”, which is generally a separate stream at secondary level that can be chosen by students (van de Werfhorst et al. 2010). Focusing on science at secondary level will guide a

science career, many of which are associated with the stereotypical belief that science is an inappropriate career for women (Steinke, 1997). The very fact that there are fewer girls/women in science is already a sign that “science” is considered a masculine domain (Kelly, 1985). Thus, the stereotypes of “masculinity of science” and that it is a male-dominated field affects the ability of girls and boys – but particularly girls - to nurture their ideas in pursuing a STEM career (Hill, Corbett & Andresse, 2010). As a consequence, few girls become interested in pursuing a STEM career.

It is therefore important to analyze this issue of female participation in STEM disciplines, since their inclusion would empower them by improving the economy, health, and infrastructure worldwide and help to fight poverty internationally with technological and scientific interventions. Furthermore, as a large number of job sectors are based on STEM education, girls and women are currently missing these opportunities by not having a STEM education to tertiary level. It is essential to fully understand the reasons for their absence in tertiary STEM education and STEM careers to achieve gender parity in STEM (TRIMUNC, 2015). This narrative review article will analyze the reasons behind having few women in STEM pipeline. To do so, “gendering science” will be conceptualized in the global context and the concept of gender roles and empowerment will be defined to analyze the issue. Arguments about the reasons why girls and women are underrepresented² in STEM careers will then be established by example using this

framework, followed by discussion of the implications of the issues raised on policy and practice.

Research Purpose and Methodology

The purpose of this article is to analyze the reasons behind female underrepresentation in STEM careers using the “feminist research methodological” approach, which allows review of the literature by “making meanings” of female underrepresentation in STEM from the “intellectual, analytical, and interpretive” viewpoints (Wickramasinghe, 2010:111). Using such approach, this article will give particular consideration to the key question: why do so few girls/young women pursue a STEM career? Girls and women between the ages of 13 and 25 will be the main focus of analysis.

Apart from analyzing the literatures from the broader feminist lens, this review article will particularly follow the structure of “Narrative Review” article which emphasizes on describing and appraising “published articles but the methods used to select the articles may not be described” (Ferrari, 2015:2). This kind of review is influential to continue education as this provides the updated knowledge of a specific theme in a qualitative manner (Ferrari, 2015).

Conceptualizing “Gendering Science”

Kelly was one of the first STEM researchers to show that science is a masculine field, and found that such “masculinity is constructed in the early years of secondary schooling”³ (1985:133). Kelly particularly

² As I am looking into this issue from the global perspective, I have not specifically focus on the problems of a particular country. However, examples of different countries or context (i.e., patriarchal society, developed country, etc.) are included to ensure the validity of my argument.

³ For this reason, my literature review emphasizes the secondary science classroom or laboratory. In analyzing the classroom interaction or environment, I have not focus on ‘math’ at secondary level, as girls’ math abilities and

drew on the work of Weinreich-Haste, who showed that “science is associated with factors such as difficulty, hard rather than soft, things rather than people, and thinking rather than feeling, all of which are part of the cultural stereotype of masculinity (Kelly 1985:135). Kelly added, “the image of the scientist is similarly not only male but also masculine in the sense of being cold, unemotional and logical” (1985:135). In this way a subject can become gendered, and we can find several aspects of masculinity and femininity in practicing it. Such practice is related to the roles played by males and females and, conversely, some also ignore such stereotyped roles by empowering themselves.

The term “gender roles” refers to the different stereotypical behaviors and traits expected from men and women by society. That means the activities of a person depend on cultural and social expectations of their gender roles. In the socialization process, girls and boys gradually develop their personality according to expected gender roles. On that basis, the boys’ characteristics that adopt the expected roles within the culture are considered “masculine” and, similarly, girls’ gender role identification is determined as “feminine”. Such socially-prescribed rules for being masculine and feminine create high discrimination in every sphere of life including the workplace and in choosing professions by creating boundaries. These socially constructed gender roles prescribe how individuals are socialized as “proper women” or “proper men”, otherwise the person will be defined as “improper” in a social setting (Allgeier & McCormick, 1983). This concept facilitates examining

the masculinities and femininities underlying the whole issue (Connell, 1999).

In this paper, I also aim to add to the existing debate on empowerment of girls and boys in how they choose their career paths in the sciences. It goes without saying that empowerment of both girls and boys is important for nurturing interest in continuing in a particular profession. Kabeer explored the concept of empowerment and precisely discussed “the interrelated dimensions” of “agency, resources, and achievements” (2005:14). Kabeer argues that agency is the “operationalization of choice. Just as all forms of choice are not empowerment, so too there is nothing inherently empowering about the exercise of agency. Agency is relevant to empowerment in so far as it represents the operationalization of strategic choices” (2010:17). Therefore, the whole process of empowerment can be understood according to the interconnectedness of the above-mentioned three dimensions.

Underlying this conceptualization of gendering science, two specific concepts will be used. The concept “gender-role” will help in analyzing the reasons behind having so few girls and women in STEM careers with respect to their roles in the society and interest in choosing a particular occupation. Then, the concept of “empowerment” based on the three dimensions will facilitate the analysis of female interest in pursuing STEM careers, which is reflected by breaking through the gender-role stereotypes of science.

attitudes are another broad aspect of the STEM argument (Shapiro & Williams, 2011).

Absence of Women in STEM Careers: A Critical Appraisal

Here I analyze the educational, attitudinal, socio-cultural, and socio-economic aspects of why there are so few women in STEM careers. This analysis introduces some important concerns that can be focused on during policy implication to ensure gender equality in STEM careers.

Educational Aspects

Blickenstaff reviewed 30 years of literature on STEM careers and found that several researchers have blamed the problem on girls' "academic preparation to be successful science students" and mentioned this as the main reason behind girls avoiding STEM careers (2005:374). While it is important to consider girls' academic preparation, it is also important to look at how boys are prepared and who prepares them. Interestingly, in almost every country including the developed ones, the majority of science teachers are male at both secondary and tertiary level (UNESCO, 2007). The dominance of male teachers and boys can pressure girls in their preparation (Ali & Awan, 2013). Is academic achievement the only reason why girls drop out from STEM subjects? Or is girls' academic preparation always poorer than boys? Of course, the answer is 'no' to both questions. It is well documented that, in spite of better preparation and academic achievement than boys, women often leave STEM at tertiary level and as a result do not obtain STEM jobs (Brainard & Carlin, 1998). It is therefore problematic to frame the underrepresentation of girls by saying that they are "inadequately prepared". This is not an issue created by girls themselves, rather the failure of institutional practice and underlying societal structures.

Researchers from various countries have "looked at the numbers of males and females depicted in illustrations and photographs in science texts, and found that a majority of the people depicted were male" (Blickenstaff, 2005:377). Additionally, if we simply search for "great scientists" in Google, we hardly find any female scientists except Marie Curie, but her success in science is usually presented together with her roles as a wife and mother rather than simply focusing on her scientific achievements in relation to other male scientists. This is problematic, as it can reinforce learners to practice stereotyped gender roles. Moreover, science textbooks often use picture where girls and women are "sunbathing", "cooking", "nursing", "nurturing children", "looking frightened", helping the "men", etc. (Blickenstaff, 2005; Walford, 1981), emphasizing the expected female gender role. Not only that, teachers often use sex-stereotyped examples like using "football" to represent the earth rather a "balloon", and then subconsciously start conversations with the boys in the classroom on how a particular football team has performed the previous week (Kelly, 1985). Such teaching techniques and media representations can over time also influence students towards the masculinity of science on the basis of their gender roles.

Therefore, the lack of female role models and media representations of girls in the educational setting can be a reason for their absence in STEM careers. However, Tai and Sadler (2001) showed that girls' achievements in physical sciences are much higher in the US when innovative student-friendly teaching designs (for both boys and girls) are used and they expressed their passion to commit to STEM careers. I consider this according to Kabeer's (2005) conceptualization of empowerment, where those girls

have enough resources and support to pursue their interest. Their agency in undertaking a science career is highly intertwined with their educational context. The educational institutions can thus lead to socializing a child in deciding his/her future interests. This example also depicts the ways in which the connotation of masculinity in science is socially constructed and the educational structure/setting is greatly responsible for having so few women in STEM careers.

Attitudinal Aspects

Several researchers found that female attitudes to science are significantly less positive than male attitudes (Breakwell & Beardsell, 1992; Erickson & Erickson, 1984; Harding, 1983; Harvey & Edwards, 1980; Hendley *et al.*, 1996; Johnson, 1987; Jovanic & King, 1998; Kahle & Lakes, 1983; Robertson, 1987; Smail & Kelly, 1984 cited in Osborne *et al.* 2003:1062). By drawing on Allgerier and McCormick's (1983) idea on gender roles, it is clear that such differences in attitude can occur due to the socially prescribed expectation of male and female roles. For example, the sex-stereotyped masculine jobs attract boys as they are expected to have highly paid jobs that provide them with position in society by strengthening their gender identity (Osborne *et al.*, 2003). Thus, boys prefer STEM or masculine jobs more to exercise the dominant modes of masculinity (Connell, 1999). Here, science content is also important to consider, and biology is more related to

caring or nurturing others and is therefore not as masculine as physics (Miller *et al.*, 2006). The visible hierarchies in science content often position biological sciences as feminine subjects less appealing to boys (Mim, 2015). It also reveals that "girls' interests center around people, boys' around control" (Kelly, 1985:136). I assume that the way girls are socialized according to gender roles, i.e., to be caring, looking after children, etc. make them more interested in choosing biological sciences⁴. That means that the masculinity of science consists of power hierarchies with men at the top who specifically practice industrialized and technological science (more than girls), stereotypically representing their masculinity. Additionally, male-dominated society lends more importance to the advancement of economic productivity and values the content of science on that basis (Blickenstaff, 2005). Again, the stereotypical gender role perceptions affect the students in nurturing their attitudes towards science.

This issue can be teased out by highlighting some of the key findings on students' perceptions of science. Miller *et al.* (2006) and Steinke (1997) found that girls perceive the lifestyle of scientists as very unattractive, with not enough time to spend with their family and the need to work in a laboratory for long periods of time wearing "boring" laboratory clothing. Such perceptions can vary from person to person, but I believe it depends on the girl's nurturing, where she sees the women in her household devoting maximum time to family and adopting that normative life-style

⁴ Research has shown that the participation and achievement of girls in biological sciences are much higher than physical sciences, which is considered more masculine in its science content (Nasr & Soltani, 2011). Moreover, Weinburgh (1995) found that the girls who like physics have more positive attitudes towards science rather the girls who choose biology. In this paper, I am not going to argue these findings as it deviates me from the main analysis of underrepresentation of women in STEM careers as a whole,

but it is really problematic how we gender the contents of science and place it at a higher level by measuring masculinity (Mim, 2015). A subject and its content should be gender neutral, because its power relations and stereotypical practices can influence male and female performance in society.

as her own. Moreover, from the beginning of life, she is expected from her surroundings to look beautiful/tidy, and Kelly (1985) found that when girls reach adolescence they become much more concerned about how they look. Thus, at secondary level, they start to think about professions where they don't have to compromise on how they look. Furthermore, girls' ways of nourishing their outlook is also their agency, where they can do it willingly but such willingness obviously differs in the way they socialize. As a result, their attitudes towards professional interests may vary on that basis.

The masculine classroom environment can result in girls' negative attitudes towards science. For instance, Whitelegg (2001) found that boys often took control of laboratory apparatus by being aggressive, and their overenthusiasm in laboratory participation can be interpreted as male dominance. By drawing on Connell's (1999) ideas on masculinity, we can consider the situation of exercising automatic priority of boys if the teacher or lab facilitators always expect the girls to be 'polite' and let boys practice their hegemonic masculinity over the physical spaces. It is worth mentioning that these physical spaces are not limited to the laboratory and also include the playground and classrooms (Mim, 2015). However, Kelly mentioned a scientific test in school laboratories where girls and boys performed equally but when asked about the experience of the test "the boys chorused "easy"⁵ while the girls said rather plaintively that "the electricity was horrible" (1985:139). In such

cases, girls are often "helping hands" for boys, where the boys take the lead in the laboratory experiments (Archer et al., 2013; Kelly, 1985). My feminist lens allows me to interpret such findings by pointing to the upbringing of girls and boys, in which they are taught to practice gender-differentiated behavior by considering girls in service roles as subordinate to men. It requires mentioning here what I exactly mean by gender-differentiated behavior, which accompanies the practice of gender roles where the girls adopt "femininity" and the boys adopt "masculinity" (Allgeier & McCormick, 1983). This is quite relevant in what Kelly said about student behavior in the science classroom: "boys bring with them to science lessons a conception of masculinity which includes toughness, aggression, activity and disdain for girls; girls bring with them a conception of femininity which includes timidity, conscientiousness, deference, person orientation and a concern for appearance" (1985:145). Hence, my argument supports and strengthens Kelly's statement.

Teachers' sex-stereotyped attitudes in science classrooms can affect students' perception of the subject and result in fewer girls entering STEM careers. For example, Warrington and Younger reported on teachers' sentiments and prediction of boys' high scores in the UK, where they claimed "boys frequently present more original work, whereas girls copy sentences from the textbook" (2000:505). Generalizing girls' underperformance and such pre-conceptions of who is meritorious and who is not for

⁵ I assume that while most boys found or pretended scientific tests were "easy", it automatically put pressure on the boys who did not find it easy and maybe they cannot raise their voice in the class being afraid of being called "weak" in the masculinized context. Thus, the alternative masculinities and girls having feminine traits are often deprived by the hegemonic masculinities of male-dominated society

(Connell, 1999). Here, I will not further discuss the alternative masculinities in this paper, but I mentioned it here briefly because we should not generalize boys and their attitudes.

“science” is problematic. It is important to find out why those girls are copying rather than blaming them directly, because girls are not homogenous and they often deal with the double burdens of home and work/study even in developed countries (Enloe, 2014). If the teachers devalue girls’ performances and predict their unwillingness towards science based on stereotypes or previous records, then girls will not be motivated to pursue STEM careers. Some studies (Brainard & Carlin, 1998; Sonnert, 1995) have focused on the point that girls left science but did not investigate why they choose a different subject. Students are allowed to choose any subject they want; it is their agency. They obviously can be more passionate about any subject. It does not mean in any way that if people are in science they are more scholarly than others. Merit can be exercised in any field. It therefore follows that it is problematic to always highlight that students “left” science. However, there are examples showing that girls become very enthusiastic about science if they are motivated and that they intrinsically appreciate science. A 13-year-old girl from Canada said about her success in physical science, “I am proud of what we built. Usually, you see men at a construction site, not women. This proves that we can get along and get the job done” (Megan in Girlsinc, 2014). Here my argument is consistent with Kabeer (2005), where I assume that such empowerment comes from the combination of her willingness and the support that she gets from her surroundings, which allowed her to go against the grain. Thus, the attitudes of girls towards sciences depend on multidimensional factors and a lack of empowerment that demolishes their consciousness can be a crucial reason of their underrepresentation in STEM.

Socio-cultural and Socio-economic Barriers

The socio-cultural ideologies of a patriarchal society expect women to be “good mothers” (Agarwal, 1997). They are expected to perform their roles as mothers, even compromising their careers (Mim, 2015). Thus, especially in developing countries, girls are often actively discouraged by parents and teachers from taking STEM careers since “successful female scientists often did not have children” and scientific careers can demand more time compared to other professions (Blickenstaff, 2005:377; Mim, 2015). Here I feel that increasing the number of science role models is not in itself enough, because society actually only perceives women as professional role models if they are equally “successful” in their family lives. Additionally, a women’s work is judged on the basis of masculine traits that she needs to have in a STEM job (Steinke, 1997). But why do girls need masculine skills in STEM? Well, the inherent notion that “science is power so science is defined as masculine” (Wallsgrave, 1980 cited in Kelly, 1985:147) plays a role in treating women that way. At higher education level, science demands more time, engagement, and financial investment, which often hinder the girls from patriarchal societies pursuing a career in sciences (Mim, 2015). Besides, parental involvement and their interest are also important. Parents with low incomes are not always willing to invest much in girls’ education, who stereotypically are supposed to be wives and mothers. Also, since the overall cost of educational in scientific subjects is higher than other subjects at secondary and tertiary level, parents discourage their daughters to take STEM (Herz & Sperling, 2004). By drawing on Kabeer’s (2005) notion of female agency, a large group of women often cannot exercise their power to choose careers in the patriarchal context. As a consequence, the above-

mentioned socio-cultural and socio-economic barriers put pressure on girls to experience the commonality of women by emphasizing their reproductive and caring roles.

Implications for Policy and Practice

The above analysis shows how several factors are interconnected and make STEM male dominated. Thus, multi-faceted approaches are needed to address this issue. To support female participation in STEM, policies like ‘Seven Transformative Actions’ of Science and Technology (S&T) have been followed all over the world since 1995, finalized at the Beijing World Conference on Women (UNESCO, 2007:48). This is the only globally recognized policy on S&T that talk about girls’ participation. On a specific note, it is important to contextualize by considering some factors like intersectionality of girls, pedagogical aspects, generational perspectives, cultural differences, etc. when implementing this S&T policy in a particular country. However, this chapter does not aim to evaluate the effectiveness of this policy worldwide, which is a huge task in itself; rather, it has highlighted certain things by problematizing the issue through a gender lens. In this section, I try to explain the implications for policy and practice based on the issues raised.

First, the arguments made in this paper claim that gender awareness in pedagogical practice is crucial, because if the above-mentioned gendered institutional ideologies change, then it will contribute to create a happy teacher-student collaborative learning environment. The extreme competitive environment and exam-based evaluation system often put pressure on all students. As the students’ needs and interests vary, they should not be expected to perform equally

well in all subjects. At the same time, it would be unfair to predict students’ abilities based on gender stereotypes, as they can self-empower in the right environment. The gender neutral teaching technique with the practices of eye contact with all students, understanding students’ needs, finding out their problems (but not in front of the class) related to their demotivation towards science, and avoiding sex-stereotyped compliments and teaching aids help students to not become isolated in class. It facilitates students to understand their own interest in particular subjects by exercising their skills, and domination of one group over another can also be avoided because teaching techniques are directly linked to students’ personal motivations towards science. Moreover, sex-based grouping and seating arrangements in exercising science are also related to this issue (Blickenstaff, 2005). If this practice can be avoided from the primary level, students will not get the chance to exercise their masculinities or femininities as such.

Second, the packaging of science is also very important to consider. In the curriculum and in classroom exercises, the latest contributions of women in STEM can be incorporated, which will not only motivate the girls but also the boys to understand new possibilities in STEM. At the same time, the femininity/masculinity continuum in textbooks can be alleviated by giving equal importance to all the sciences (Miller et al., 2006). Additionally, the classroom management technique and representation of role models can work as a hidden curriculum that may affect students’ interests (Kelly, 1985). Considering intersectionality is very important in designing lesson plans to better understand students’ interests because their family environment, geographical background, and life struggles are

completely different. Furthermore, sometimes both teacher and parents give extra importance to science than other subjects by framing it as a more difficult subject, which can affect the students. If we make it more student friendly by focusing on how science helps us in daily life, it will help both girls and boys to enjoy the benefits of science rather its masculine image.

Finally, the practice of gender stereotyping and intergenerational power relationships in families regarding girls' stereotyped gender roles hinder their career choices in STEM by overemphasizing the educational costs and their futures as women. Therefore, if we consider those gendered issues while implementing or designing STEM policies and practices, it will contribute to mitigating this multi-faceted issue at least in part.

Conclusion

Biological differences are a fact of life and should not be used to judge students' abilities and interests in a particular subject (Shapiro & Williams, 2011). This article highlights the socialization process of young students (especially girls), who are expected to perform their stereotyped gender roles consciously or subconsciously both in the family and educational

settings. These gendered ideologies are clearly interlinked to the career they become interested or influenced in. Moreover, the impact of the masculine image of STEM can naturally exclude girls from the domain, but I do not suggest having "girl-friendly" or "feminine science" at any educational level or even in STEM jobs. The subject domain and job sectors should be gender neutral, and we need to emphasize the life experiences and interests of everyone by being gender aware in family relationships and pedagogical practice using a collaborative approach. Besides, the practice of hegemonic masculinities in a knowledge domain can be a danger to not only the girls but also to some boys, as it emphasizes the existing intergenerational power relationships in a patriarchal society (Connell, 1999). Thus I highlight not how boys are obtaining advantages in STEM careers all over the world, rather how we deprive both girls and boys by putting pressure on performing gender roles, which demolishes their innate potential and a wide range of possibilities in advancing STEM.

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