



Understanding Barriers and Supports for Women's Progression in STEM in Kazakhstan

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INTRODUCTION

Science, technology, engineering, and math (STEM) remain a vital field for any country's economy as the advancement of technology depends on STEM fields (Green & Sanderson, 2018). Due to the competitive status of the global market, there is a growing demand for qualified individuals in STEM fields. Although there is a continuous effort to reduce the gender gap in the labor market (WEF, 2023), women continue to face barriers to involvement in all fields of economic activity, including STEM.

The importance of bridging the gender gap in STEM fields is based on the premise that no country will succeed without benefiting from women's talents. As women constitute over half of the world's population, it is very important to close the gender gap in the critical sectors of the economy, such as STEM. Women entering technical fields can

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address the shortage of qualified personnel in STEM (Burke, 2007; Hill et al., 2010). Enhancing gender equality in STEM fields will increase the number of qualified personnel, improve the country's competitiveness in the global market, and strengthen its innovative capacity. Addressing the gender gap in STEM will also reduce the need for job outsourcing and import research and innovation from other countries.

Although overall, women's participation in STEM education has increased internationally, women have not always been successful in entering STEM employment and continue to be filtered out of the STEM workforce (European Commission, 2020). The global employment rate for women in STEM sectors is 54% compared to 81% for men. In Kazakhstan, the tendency is consistent with global findings. According to the Ministry of Science and Higher Education, female students comprise 53.8% of the overall student population. In the 2022/23 academic year, 308,600 female students and 268,700 male students were enrolled in HE programs across Kazakhstan (Bureau of National Statistics, 2022). Meanwhile, the number of women enrolled in STEM majors in Kazakhstan constituted only 31%, with a striking imbalance of only 26.6% of women in such specialties as Information and Communication Technology and 78.7% in Social Sciences (Bureau of National Statistics, 2022). The gender gap proceeds at higher competitive levels, with only 25% of women being employed in engineering and digital sector jobs (Kuzhabekova et al., 2024).

In this contradictory social and economic context, education systems play a critical role as there is a need to support girls' interest and motivation in STEM from an early age. This suggests that teaching and learning environments need to integrate gender equality into their teaching practices. Many countries have succeeded in reducing the gender gaps in educational attainment and achievement. Notably, Kazakhstan displays equal performance in international assessment, with female students performing equally well and even outperforming male students in science (OECD, 2019), which reflects the country's intriguing "gender paradox," as highlighted by Durrani et al. (2022). Kazakhstan boasts high literacy rates (Almukhambetova & Hernandez-Torrano, 2021; Winter et al., 2022) and a trend of women outnumbering men at all levels of education, yet it faces challenges related to women's underrepresentation in political and economic spheres of life. Kazakhstan is also considered to be a leader in progress on gender equality among other Central Asian countries with

62nd position among 146 countries in the Global Gender Gap report (World Economic Forum, 2023).

Based on the theoretical taxonomy of supports and barriers (Fouad et al., 2010), this chapter aims to explore the reasons for women's underrepresentation in STEM in Kazakhstan along with the barriers and supports across three developmental stages: childhood, adolescence, and adulthood. Previous research has focused more on psychological factors that prevent women from participating in STEM and has focused less on understanding the external influences beyond women's personal characteristics, such as supports and barriers that might encourage and discourage girls and women from pursuing STEM education and employment. Meanwhile, there exists evidence that environmental supports play a facilitating role in women's engagement with STEM, whereas barriers can impede their retention and progression in STEM. The chapter seeks to identify the barriers and supports that influence women and girls' retention in STEM educational and career pathways in Kazakhstan across the developmental levels.

OVERVIEW OF PREVIOUS RESEARCH

The systematic filtration of women from STEM has received substantial scholarly attention from leading theorists and researchers who have tried to understand the factors behind female underrepresentation in STEM fields. A number of studies have been conducted to analyze the reasons why girls and young women do not succeed in STEM (Henriksen et al., 2015; Mainhard et al., 2018; Microsoft, 2017; Stoet & Geary, 2018).

A substantial part of the literature on this topic is based on the theoretical argument that women's lack of progress in STEM areas is linked to internal aspects of women's choices, i.e., their expectations of success and the subjective value of tasks related to STEM (Eccles, 1994; Kuchumova et al., 2024). Previous research also identified that women display lower self-confidence in their ability to perform equally well with men in STEM, and this is one of the major reasons why they do not persist with related careers (Rittmayer & Beier, 2008). However, less scholarly attention has been paid to external facilitating and impeding factors beyond the women's self-efficacy beliefs, i.e., supports and barriers that girls and women encounter in their schooling, study, and career socialization experiences (Fouad et al., 2010).

One of the most useful theoretical schemas that helps to understand the dynamic process of developing interest, making career-related choices, and achieving success in related education and occupational pursuits is the Social Cognitive Career Theory (Lent et al., 2000). However, as mentioned earlier, the scholars using this theory mostly focused on individual-level influences rather than looking at the complex interaction between internal and external influences. According to Fouad et al. (2010), the most fruitful inquiry should include the role of environmental factors in order to understand women's recruitment and retention in STEM education and careers.

Supports and barriers are defined as environmental influences that either facilitate or impinge the development of interest, attitude, and skills (Lent et al., 2000). Many studies have identified the personal characteristics that influence and hinder or promote women's engagement in STEM but overlooked the external environmental factors (Swanson & Tokar, 1991). The studies also seem to have overlooked the investigation of barriers and supports across the stages of education and career development (Fouad et al., 2010).

Previous research in the Kazakhstani context identified that girls aspiring to choose STEM majors often lack confidence in their abilities, mostly caused by the influence of social stereotypes that STEM is not a female domain. Being able to perform equally well with men, women students in Kazakhstan also get contradictory messages from the surrounding environment about their ability to succeed in STEM-related jobs (Almukhambetova & Kuzhabekova, 2020). Other studies conducted in the context also concluded that major school-related factors of women's underrepresentation in STEM are the teachers' lack of gender awareness (Almukhambetova, 2024) and the gendered messages in school textbooks (Durrani et al., 2022). This study will continue this line of research by investigating the supports and barriers that predict girls' and women's engagement with STEM and subsequent progression in STEM education and careers in the context of Kazakhstan. The focus on all developmental stages is particularly important as certain supports and barriers may bear a different significance at different stages of girls' and young women's progression in the stages of the STEM pipeline.

There are several ways in which this chapter contributes to existing research. First, the study fills the gap in the current understanding of women's experiences at all developmental stages by bringing additional insights into supports and barriers that affect girls' and women's

intentions to pursue education and careers in STEM. These insights complement the previous studies, which mostly focused on women's experiences in formal education only. Second, the proposed study offers an understanding of the environmental influences of women's underrepresentation in STEM careers in a non-Western context, supplementing the predominantly Western perspectives on the phenomenon with insights from a new context.

METHODS

The chapter is based on the data collected by the author from five years of research on female students' and university graduates' experiences in STEM education and transition to employment in Kazakhstan. This chapter employed a qualitative secondary analysis of interview data from these projects (Heaton, 2004). The purpose was to explore external environmental factors (based on SCCT theory) to understand the supports and barriers to gender equality in STEM fields using the data collected from 2 projects conducted between 2018 and 2023.

Each project employed a purposive maximal variation sampling to recruit the participants. The combined sample is diverse in age, marital status, STEM domain, and geographical distribution. The overall sample comprises 65 young women aged between 19 and 24. The main data collection tool included semi-structured interviews with young women who were studying STEM majors, were in the process of looking for jobs, or were employed in the STEM sector. Forty women were pursuing their undergraduate and graduate studies at the time of the interview, 10 students were looking for employment, and 15 women were already employed in the STEM sector for not more than 2–3 years. All the participants were required to complete the informed consent form and to express their agreement to be audio recorded before the interviews began. The interviews were conducted by the author and several research assistants involved in both projects. All interview data was transcribed by the research assistants prior to data analysis.

To address the main research question, "What are the main supports and barriers to women's retention in STEM education and careers as experienced by young women?" the author categorized supports and barriers as viewed by female participants. The author used a constant comparative method to code the data in order to pick up young women's

reflections on supports and barriers they have encountered in their STEM educational and career pathways at different developmental stages (Saldana, 2021).

FINDINGS

The overarching purpose of this chapter is to synthesize and summarize the multidimensional barriers that affect, impede, or prevent girls and women from choosing STEM educational/career trajectories and the supports that facilitate their advancement and retention in STEM career trajectories across three developmental stages: childhood, adolescence (high school and university study), and adulthood (professional life). The life course of any individual is constituted of sequences of experiences at different stages (Elder et al., 2003). Previous research on STEM career pathways was mostly focused on educational transitions paying less attention to developmental stages. Meanwhile, investigating gender inequality from a life course perspective (Elder et al., 2003; Sheppard, 2009) might give the full picture of women's experiences in STEM in childhood, adolescence, and adulthood, which shape their educational and occupational choices as well as systemic issues they encounter in these stages. The following sections of the chapter summarize the supports and barriers experienced and reported by young women who pursue education and careers in STEM in Kazakhstan in each developmental stage.

Barriers in Childhood

Female underrepresentation in children's books and cartoons was highlighted as one of the barriers to girls' engagement with STEM at an early age. As participants noted, in children's books and cartoons, there is a lack of female representation, and some stereotypical images are associated with professions. Only men are depicted in STEM jobs, such as engineers or scientists, and women are pictured having stereotypically feminine jobs, like nurses and teachers. Meanwhile, as many participants noted, it would be much more encouraging for girls to have books and cartoons with female lead characters with STEM jobs. This can be evidenced in the following comments:

We need more children's books with girls engaged in STEM (...), and we need to encourage parents to show these books to their children.

Even the cartoons...now we have a distinct division- cartoons for girls... cartoons for boys... girls always play with dolls, and boys play with Lego kits. Why don't we let the girls play with Lego too?

The quote above also highlights the agential potential that “girls” and “boys” toys play in children’s development and gender socialization, as they might mold the children’s perceptions of gender roles and limit their future prospects.

The lack of female role models was named as one of the important barriers to girls’ engagement with STEM in childhood. As one participant stated, when she was a child, there were no female role models, but one day, she paid attention to a picture of a woman wearing the uniform of a STEM worker:

We need to advertise the image of women working in technical fields. Like, for instance, when I was a small girl, I saw a picture of a woman wearing a uniform, and then I started to dream of wearing such a uniform. Now I wear a uniform. Many girls might want to wear uniforms, the same as I did.

Low parental expectations of girls’ success in STEM, low parental involvement in girls’ studies, and lack of confidence in girls’ abilities were also identified as strong barriers to developing girls’ interest in STEM education and careers. Several young women mentioned that their parents never displayed any interest in their engagement with math and science subjects, and this has significantly impeded their interest in STEM domains at an early age.

Barriers in Adolescence

As girls grow up, they seem to continue to face barriers in their STEM educational pathway. Several participants stated that one of the barriers to their engagement with STEM in adolescence stems from the fact that girls have less time for study as they spend a lot of their out-of-school time on household chores, helping their mothers around the house or taking care of younger siblings, whereas boys have more time for studies and real-life STEM experiences. As one female participant commented:

My male classmates have higher academic performance in STEM subjects. From early childhood, girls are expected to do the household chores-and this really takes a lot of time... boys do not have these responsibilities...If I had a chance only to go to classes and solve math problems all the time, I would have achieved the same as my male classmates.

At this stage, many girls graduating from school possess the required skills to succeed in the STEM majors at university. However, they are less likely to pursue these specializations. This mostly happens due to the informal genderization of professions and a lack of parental and familial support when choosing a STEM-related educational pathway when finishing school. This lack of support destabilizes the girls' confidence and raises their doubts about the appropriateness of choosing STEM specializations. One participant commented that she was very unconfident in her choice of the STEM major due to the lack of support from her parents: "Both of my parents were against my decision to enter the STEM major. They told me that technical specialties are not meant for women, not for girls ...they are too difficult."

It seems that as the girls transition to adolescence, the parental influence on girls' overall engagement with STEM and decisions regarding STEM-related education becomes more pronounced. While in childhood, girls experience low parental expectations of their abilities in STEM, during adolescence, some parents start to actively discourage their daughters from choosing STEM higher education, voicing doubts about the suitability of STEM specialty for women and STEM being harder for women to handle. This leads to a decrease in girls' self-confidence and instills doubt about their capabilities in STEM.

The young women almost unanimously stated that the dearth of female role models working in STEM was an important discouraging factor at this stage of life, as it could devalue girls' self-perceptions and abilities in STEM and lead to a failure to realize their STEM career aspirations and potential. The role models of the same gender might inspire the girls aspiring to have a STEM career to pursue and emulate the same achievements. Another related barrier at this developmental stage is a lack of career counseling. It was also highlighted by interviewed women that during the last year at school, the students should be provided with career counseling as they need to understand more about what the STEM specialty entails. As highlighted by one participant, there needs to be a close connection between the school and STEM companies, and

career counseling should involve attending the open house days for school graduates in STEM companies, labs, and factories:

It seems to me that all this needs to start from the elementary grades. We need to take the school students to STEM companies and organize open days for them in laboratories... to understand what they can do in the future. Instead of guessing, "Maybe this will be more useful for me. Maybe this will be more profitable for me." This is a really difficult choice. If I were the Minister of Education, I would change the system. Take them to factories to see all this and allow them to see everything from the inside so that they will imagine themselves in this field in the future.

Gender-biased treatment in the classroom context was also mentioned as one of the important barriers to girls' engagement with STEM in adolescence. It seems that girls often face unfavorable treatment and negative comments from STEM school teachers and university instructors regarding their abilities in STEM, which solidify their self-doubts about STEM, previously instilled by their parents in childhood and early adolescence. The teachers also do not consider the household chores the girls are often burdened with. As one of the participants commented: "The teachers always favor boys...." Overall, the lack of gender-responsive pedagogy in STEM classes at school and university was highlighted by the majority of participants:

I used to experience this in my Bachelor's studies. You know, this is actually 'a car manufacturing' what I was studying. And this was easier for guys, for boys to understand the subject, to relate it to this car manufacturing, and when even the professors were explaining the material, they were saying, "Well, girls, you might have some problems in understanding this."

The fact that it is easier for male students to understand the subject mentioned in this quote also relates to the role of children's toys in gender role socialization mentioned in the previous section. Male children play with STEM toys (cars, LEGO kits) in early childhood and this gives the advantage of grasping quicker the subject matter. In addition to that, the learning materials at schools are also heavily gendered. This also internalizes the inherent suitability of STEM for boys.

Barriers in Adulthood

Being a woman in some STEM majors means being a lonely venture in group projects. Many participants reported that the low number of female students in STEM courses made them feel isolated and insecure. My analysis also identified that those female students who faced subtle bias from their male peers in their senior years at university were less clear about their belonging to the STEM profession and more likely to leave STEM. Furthermore, subtle discrimination and low encouragement from STEM course instructors were important barriers to further progression with STEM career intentions. As one participant noted, “We had a course instructor; he was responsible for the lab assignments, and he was a postdoc. He openly discriminated against the girls. It was so unpleasant and...ridiculous.”

The interviewed women also mentioned the challenge of having competitive rather than cooperative learning environments in their STEM university departments. Also, the fact that there was a low number of female course instructors was reported to be related to a lack of support and mentorship in male-dominated classrooms, increasing young women’s feelings that they do not fit the STEM domain and need to move to other, “more suitable areas.”

At this developmental stage, many young women plan to start or have started their family. Several participants reported being constrained by the expectations to prioritize their marriage and family. Although they also aspire to build a successful career in STEM, the likelihood of opting out of the highly demanding and competitive STEM field during this period increases. It was also noted that although the parents’ role decreases at this developmental stage, young women still get advice from their parents about choosing the jobs that are more suitable for future marriage and their role as future wives. As participants commented, this is one of the reasons that young women confront the choice—either to prioritize a career or family life and find it difficult to opt for both.

One illustrative comment: “My parents say: if you have children, who will look after your children or all these things...your future husband might be against that.”

Other similar comments:

In Kazakhstan, girls are treated like, uhm, weak gender...girls are not supposed to be engineers and need to stay at home and, like, raise children,

be a good wife, and everyone is ...following this kind of strategy...that is because maybe it is a little bit hard for women here to become engineers. All the challenges women face at that time are connected with their future families and husbands. Because they may not like their profession... After marriage, girls do not really prioritize careers. That's why many girls put their careers and their education astray, prioritizing marriage over all.

At this developmental stage, it becomes particularly difficult for married women to maintain a work-family balance. Many women already employed in STEM are constrained with caregiving responsibilities at this period of life as they are parenting small children and face a lack of spousal support. They often fail to achieve a balance between work demands and family responsibilities, and this leads to giving up the STEM career pathway. As one participant commented:

I want to create my own family, give birth to children, and give them a proper upbringing... But, on the other hand, I really want to build a career, continue my studies, and go abroad. And it is very difficult to combine both if there is no support.

It is particularly challenging for married women to keep up with the quick development of the STEM spheres, having children, and trying to maintain a work-family balance. One woman working in the telecommunication industry commented:

There are more obstacles, in fact, than supports. Because technology is developing very quickly and keeping up with it, having other responsibilities is very, very difficult, especially for women. Because, well, after all, traditionally, no matter how we say that we are a very progressive country...all that. Nevertheless, a woman has a lot of responsibilities around the house and children. And it's very difficult to keep up with all this progress, and I was hopelessly behind, I thought. That's why I also gave up, well, I sort of gave up trying to develop further in the telecom industry because I missed too much; it's practically impossible to catch up... I believe that women have no advantages in this industry. As they have to compete on equal terms against great obstacles.

Furthermore, women also experience such barriers as indirect and direct discrimination during the job search process after graduation. Many women confirmed that they faced male-oriented hiring practices during

the recruitment and selection process mostly because employers prefer hiring male applicants as they conform to the “ideal worker” image. The employers also seem to hold the stereotype that men are naturally more skilled in science and math than women, and women are viewed as less suitable for certain STEM positions, as encapsulated by the following quote:

They expected to hire the young guy for this position [IT developer], not a married woman. And you just keep applying again and feeling that you are not even considered... even for a junior developer position...

One of the participants also recalled that she was asked questions about the age of her children during job interviews in several organizations. She also said that it took her a while to get the job offer, mainly because she had two children of an early age. In addition, women aspiring to STEM-related jobs usually lack personal connections to find employment in STEM, as male employers tend to circulate information about vacancies among friends and colleagues.

I tried to find a job in this field, but it was a bit difficult. I was often not invited to interviews; well, I have no work experience, so I sort of understand. But after the interview, I often noticed that the fact that I am a woman and have two small children had an impact.

Other forms of indirect discrimination and the signs of male-oriented organizational culture in STEM companies were also reported. Several women employed in STEM organizations recounted that women's success was often left uncelebrated compared to male colleagues. Another participant pointed out the differential treatment between men and women in her organization and strong employers' assumptions that women are less capable than men and less committed to work. As she reflected, she often experienced bias in professional evaluation and noticed strong employers' beliefs that women are “the weaker” and “less intelligent” gender:

They [employers] are not supposed to distinguish them [workers] like the weak and strong genders. And the tasks are supposed to be allocated equally as well. So, let's say the man is doing this task, and women should do the same task. So, you get to choose equality, and that is all, I think.

Sexism in the workplace emerged as a recurring theme in the interviews with women employed in STEM. Several women highlighted the bullying behavior of male colleagues and the discouraging working environment.

Ok, if there is a young woman wearing a helmet on the construction site, one of the men working there would say, "What are you doing here?" Maybe it is because girls go there wearing makeup and looking nice. [A woman in a full uniform] looks apparently a little strange for them [men]

Supports in Childhood

The development of interest in STEM starts from an early age. Therefore, early exposure to STEM was mentioned as one of the major supports for developing interest in STEM. Several interviewed participants highlighted the difference in how men and women develop their STEM interests, noting that men are socialized differently and have a different degree of exposure to STEM-related activities in their childhood. Therefore, it is critical for girls to have even a little exposure to STEM-related experiences in childhood, as it is a strong supporting factor in their engagement with STEM in the future. Little exposure to STEM-related activities was also named as the reason why women and men have different levels of preparedness and skills in STEM. As one participant noted:

It definitely matters if you are exposed to STEM from an earlier age... For instance, when I was young, my father and I used to repair small things in the house. I think this is how I developed my interest in STEM.

Parental presence in STEM was also reported to be associated with girl's success in STEM educational and career pursuits. Ten interviewed women highlighted that they engaged with STEM due to the influence of their parents. This was especially evident among those female participants who decided to follow in their parent's footsteps. A female participant shared that the fact that both her parents worked in the STEM field influenced her decision to choose a STEM career. She highlighted that she received strong support from her parents through their education:

My father teaches Math at Aktobe University. My mother is also a faculty member in the IT department. Looking at my parents, I grew up with the understanding that Math and Computer Science are the top specialties.

My father used to say that Math is the queen of science...and if I choose a math-related specialty, this will give me a lot of flexibility with STEM-related jobs in the future.

Male family members' encouragement and advice were found to be particularly important for the girls aspiring to connect their lives with STEM-related educational pathways. As several participants commented, they started to develop an interest in their childhood due to a father's or brother's support in STEM-related activities. An illustrative comment:

My elder brother is an electrician. From childhood, I liked to watch him doing something ... I also liked to disassemble things to see what was inside and then assemble them together. My brother then asked me whether I wanted to become an electrician, too.

Also, most young women- participants who were already employed in STEM reported that their family members who worked in a STEM-related field could familiarize them in early childhood with STEM professions and discredit the belief that STEM jobs are difficult. According to participants, this was the major support that they have received in their STEM educational trajectory.

Supports in Adolescence

Participation in STEM activities (both structured and unstructured) was highlighted as a strong supporting factor for girls' engagement with STEM during their last years at school. Many interviewed participants reported that participation in such after-school STEM activities as robotics clubs and IT camps has boosted their desire to work in STEM. Several young women also highlighted that their participation in STEM Olympiads and competitions in science subjects was also a strong supporting factor of their engagement in STEM.

I participated in the regional chemistry Olympiad when I was in Grade 10. In 11th grade, I participated in the Physics Olympiad. I got the first prize and was also told I would be awarded the Rector's stipend in case I entered the university...It was a big motivation for me.

Several participants also noted the importance of having a STEM teacher mentor who can facilitate the students' interest in learning STEM

subjects. As one participant noted, "...it usually happens like this: if you have a good teacher, you become interested in this subject, and you keep this interest for a long time." A similar comment from another participant:

At NIS...we had very good teachers. They, for example, tried to support the girls when we had problems. When we did not understand, they explained and dedicated more time to us. In our class, the guys could quickly grasp information and understand it. Therefore, teachers tried to spend more time explaining and conveying all this information to girls.

The availability of resources in STEM subjects at school, as well as the focus on STEM subjects in specialized schools, also seems to strongly facilitate the girls' intentions to pursue education and careers in STEM. According to the participant:

My school was with a concentration in Chemistry and Biology, therefore they paid more attention to developing interest in these subjects. The lessons were engaging and we had Chemistry laboratories where we could do different experiments.

At the university level, girls who were able to find like-minded peers in university courses and group projects reported more engagement with STEM and were more likely to proceed with their career intentions. As one participant shared, she really enjoyed studying with like-minded peers: "I can't say that I'm the smartest in my group. But we support and motivate each other and do all the difficult assignments together."

Another important facilitator is the encouragement from the STEM course instructors, especially of the female gender. It was also noted by the participants that they did not have many female STEM course instructors.

Supports in Adulthood

While reflecting on the available support at this developmental level, several women highlighted the importance of professional development opportunities. As one woman highlighted, the STEM industry is very demanding and requires a lot of professional and self-development: "It [STEM industry] requires constant training, a lot of time that should be dedicated to self-development, getting new knowledge...." As

women stated, these professional development opportunities are particularly important for women returning to work from maternity leave so that they can integrate successfully after a long leave:

Yes, being on maternity leave for three years is, on the one hand, good for a child, but for a career, it is still a big loss... I think that perhaps women... could be offered some free, off-the-job courses. Maybe after maternity leave... for example, a month or two, somehow give her the opportunity to look around and come to her senses after such a break.

Connecting young women with successful role models working in the field is critical. It is also important to connect women professionals with other women working in the same specializations through forums and professional associations, like the Association of Women Engineers and similar organizations.

Several young women noted that to succeed in STEM, it is better to marry someone who also belongs to the same field to form team-like relationships in the family. As one example, one of the interviewed women working in the IT sphere noted that she benefits a lot from the support of her husband, who also works in a similar sphere. As she commented: "My husband usually contributes even more to the house. Sometimes, he has to cook, and sometimes, he cleans the house, but mostly, we share the responsibilities. This helps me a lot." "It's much easier to have a supportive family...there are some families in which the spouses can achieve a lot by moving together towards common goals."

DISCUSSION

This chapter set out to extend the current understanding of supports and barriers that assist and challenge women in STEM education and career pathways in three developmental stages-childhood, adolescence, and adulthood. Previous research on STEM career pathways was mostly focused on educational levels, paying less attention to developmental stages (life course perspective). The life course perspective (Sheppard, 2009) on supports and barriers for women in their STEM education and career track presents a more comprehensive picture of women's experiences in childhood, adolescence, and adulthood, which shape their education and occupation-related choices at these stages. This perspective was also important for understanding the life cycle of recurrent gender

inequality of “disempowered girls growing into disempowered women” (Sheppard, 2009, p. 238).

The findings are consistent with previous studies in the field and indicate that girls’ and women’s engagement with STEM in childhood and intentions to pursue education and a career in STEM in adolescence and adulthood is influenced by a number of environmental factors, which serve as either supports or barriers (Fouad et al., 2010; Merayo & Ayuso, 2023; O’Connell & McKinnon, 2021). It is evident from the study that girls and young women were hindered by barriers related to gender role socialization, lack of female role models, low number of women in STEM classes, subtle gender bias and direct discrimination, lack of career guidance, and issues related to negotiating a work-life balance.

The study also identified some factors that appeared to support girls’ and women’s progression in STEM education and career trajectory, such as early exposure to STEM, participation in STEM school and extracurricular activities, and professional development opportunities.

A core finding from this study is that women are strongly dependent on external social agents, such as parents, teachers, peers, employers, and spouses, in all developmental stages. The impact of social agents was also corroborated in previous studies (Henriksen et al., 2015; Mainhard et al., 2018). Although the influence was found to be somewhat different at each developmental level, the study identified some common influences. Such factors as familial and parental support were found to be critical across all developmental stages, especially in childhood and adolescence. The teachers’/instructors’ mentorship and encouragement for the girls were also found to be crucial in adolescence and adulthood. It was identified that teachers and university instructors could play a dual role, either supporting the girl’s and young women’s interest in STEM and providing mentorship or discouraging them from being engaged with STEM. It should be noted, however, that in the current study, young women were more exposed to gendered teacher discourses and practices both at the school and university levels.

Overall, social agents seem to exert a significant influence on young women’s educational experience and career choices as women tend to rely on relational experiences, and external encouragement is very important for them (Zeldin et al., 2008).

The study has also identified that women actually experience more barriers than supports as they progress in their STEM education and career trajectory and underscored the issues related to unfavorable hiring

practices, employers' bias, and workplace sexism (Rosser & Lane, 2002). The problem of girls and women being unable to identify female role models at all stages of their development also requires special attention. Not knowing female role models in childhood and adolescence and having few female role models in their immediate environment (mothers, female relatives, STEM university instructors) is a strong discouraging factor for choosing STEM studies and subsequent careers (Cheng et al., 2020; Microsoft, 2017). It seems that images of women actually working in STEM fields are particularly powerful as they serve as aspirational models for girls and encourage them to envision themselves in similar roles, while STEM female teachers and course instructors offer relatable mentorship and support in educational contexts and help to create an inclusive and equitable learning environment.

CONCLUSION

This chapter contributes to the existing literature on STEM women's pathways by qualitatively examining environmental supports and barriers that girls and women experience in all developmental stages, from childhood to professional life. It also presents STEM women's reflections on how these supports and barriers have influenced their engagement with STEM and intentions to pursue STEM education and careers.

Limitations

The results of this study should be considered within the context of possible limitations. The first limitation is that the two projects did not use the same interview guide and were not focused primarily on the exploration of supports and barriers. However, the influence of environmental factors was raised as a key theme in both projects. The second limitation is that the selection criteria (convenience sample) and a relatively small sample of women involved in the study preclude the generalizability of findings. Participation in this study was voluntary, so the findings derived from this sample might differ from those who did not volunteer to participate. Future quantitative research needs to involve larger samples of women students and women employees of STEM organizations to understand more the multitude of supporting and impeding factors and their impact on women's participation in STEM. Longitudinal studies would also be helpful to better understand the perceived supports and barriers over the life span.

Implications

The findings from this study suggest certain implications for practice. The study's findings indicate that in order to address the issue of underrepresentation of women in STEM fields, the measures should be implemented from early childhood, as this is a critical period for the formation of interest and attitudes toward STEM. Parents should be aware of the positive influence of early exposure to role models and the importance of providing their children with a diverse range of toys. By providing equal access to STEM educational resources and gender-neutral learning materials from an early age, parents can help to level the playing field for all children, regardless of their gender. Media should be mindful of the messages they convey via cartoons and children's programs.

There is also a need for institutional policies at the school level to support adolescent girls in the process of choosing higher education majors and providing gender-responsive instruction and mentoring opportunities via structured and unstructured activities. Schools should also be responsible for providing training for teachers and family members to ensure that they encourage and support girls in their education and career pursuits. The study pointed out the absence of role models working in STEM, which limits young women's understanding of professional choices and career prospects in all developmental stages. Therefore, more attention should be paid to the promotion of images of successful women in children's books and school textbooks to serve as role models for girls who aspire to pursue education and careers in STEM.

Higher education institutions should provide comprehensive career development support for female STEM students, including internship opportunities, networking events, and professional development workshops. They should also actively collaborate with industry to create pathways for women to enter and succeed in STEM careers. Universities should also address the existing bias in teaching and assessment in STEM disciplines through awareness-raising and gender-responsiveness workshops. STEM departments should strive to increase diversity among the faculty members. Having female faculty members to serve as role models and mentors for female students can contribute to a more inclusive learning environment.

STEM organizations need to revise their hiring practices to mitigate bias in candidate selection and hiring process. Employers should also support work-life balance initiatives to enable women to manage their

personal and professional responsibilities. STEM organizations should also offer professional development and promotion opportunities for all employees regardless of their gender. They also need to ensure that no pay gaps exist within organizations. Employers should also provide diversity training programs to raise awareness of unconscious bias and promote inclusive behaviors among employees.

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