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Participation of Girls in STEM Education: An Exploratory Study at BS Level in District Swabi

Dr. Muhammad Ishaq[1], Marwa Naseem[2]

1. Lecturer, Department of Sociology, Abdul Wali Khan University Mardan, KPK, Pakistan.
2. MPhil Scholar, Department of Sociology, Abdul Wali Khan University Mardan, KPK, Pakistan.

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Corresponding Author:
Dr. Muhammad Ishaq
Email: isak700@awkum.edu.pk

Abstract: *Even though gender inequality in STEM education is a global concern, things have not substantially changed in developing nations like Pakistan. The study on women's participation in STEM education in the context of Pakistan is still somewhat narrow. Therefore, this study investigates the sociocultural factors affecting girls' participation in Science, Technology, Engineering, and Mathematics (STEM) education at BS level in District Swabi. Previous studies show that the number of women in STEM fields is still disproportionately low, even after awareness campaigns and policy reforms. The objectives of the study are to explore sociocultural factors affecting girls' preference for non-STEM over STEM. To explore sociocultural factors girls' choice among STEM subjects and to find out issues faced by girls enrolled in STEM education. A qualitative research design was employed to explore sociocultural factors that affect girls' participation in STEM education. In-depth interviews were conducted with 15 female students enrolled in STEM fields. The interviews were recorded, transcribed, and analyzed using thematic analysis to identify patterns and themes. The key themes emerged from the data are gender stereotyping, family influences, nature of jobs associated with STEM. Findings indicate that structural reforms alone are insufficient unless accompanied by shifts in sociocultural attitudes that position STEM as a male domain. Theoretical framework such as Expectancy- Value Theory provides a comprehensive lens for analyzing these influences. Policymakers, educators, and development professionals who want to improve gender parity in STEM and progress the country's technical and socioeconomic development should consider the implications.*

Introduction

In sociology of education, STEM is used to refer to a set of subjects taught at secondary and higher secondary school levels such as science, technology, engineering, math and chemistry (Xie et al., 2015). STEM fields refer to science, technology, engineering and mathematics respond to the rapidly evolving technological landscape as the jobs of the future promoting sustainable development, inclusive growth, social well-being and innovation. Predictions highlight the need for STEM and ICT skills in the workplace

of the future, with multiple sources estimating that these competencies will be necessary for roughly 75% of occupations (EQUALS and UNESCO 2019). However, there are a number of obstacles that prevent girls from choosing STEM careers because they are not willing or able to. Women make up a small percentage of the advanced digital technology. For instance, women make up just 22% of all professionals in the global artificial intelligence (AI) industry. All 20 of the top nations with the largest concentrations of AI workers exhibit this disparity.

According to the United Nations Educational, Scientific and Cultural Organization, (2020) and the World Economic Forum, (2019) gender disparities in STEM fields are still present and unlikely to disappear soon. Women are less likely to participate in STEM programs and work in STEM-related professions as professionals throughout the school- to- career pathway (World Economic Forum, 2019). What leads to these gender disparities? The existence and early development of gender stereotypes is one explanation that could apply (e.g., Boston & Cimpian, 2018; Cheryan et al., 2015). Such stereotypes have the power to influence the interest and aspirations of both boys and girls, directing them toward particular areas and away from others. Previous studies have examined how children's gender stereotypes about particular intellectual fields, including math and science, develop and what consequences they have (e.g., Cvencek et al., 2011, 2015; Galdi et al., 2014; Star & Simpkins, 2021; Steffens et al., 2010). However, negative perceptions of girls and women are also maintained by domain-general preconceptions regarding the intellectual abilities of men and women (Bian, Leslie, & Cimpian, 2018; Bian et al., 2017; Jaxon, Lei, et al., 2019; Syzmanowicz & Furnham, 2011).

As a Commonwealth member, Pakistan is in dire need of STEM workers because the country has fewer STEM professional overall than industrialized nations (UNDP, 2013; Mujtaba & Reiss, 2015). Females are seriously underrepresented in STEM education in Pakistan, as was previously mentioned. But unlike the developed world, Pakistan has not seen rise in scholarly interest in the underrepresentation of women in STEM fields (Mujtaba & Reiss, 2015). As a result, there is insufficient research on Pakistani women's involvement in STEM education.

Theoretical framework

The present study is guided by Expectancy-Value Theory. The Expectancy-Value Theory was initially proposed by Atkinson in 1964 and was further developed and used within educational psychology by Jacquelynne Eccles and most recently, Wigfield (Atkinson,1964; Eccles, 1984; Wigfield & Eccles, 2000). In this study Expectancy-Value Theory is used to understand how girls' beliefs about their abilities (expectancies) and the value they assign to STEM subjects (task value) are shaped by external influences such as parental support, female role models and gender stereotypes etc. Encouragement to pursue studies in mathematics or technology from important individuals (family, schools and others) has a significant impact on adolescents' decision to pursue careers in STEM fields. According to the theory expectancy the conviction that one may succeed at a task and value the perceived significance, utility, and personal relevance of the task are the two main factors. The findings of this study are very consistent with these ideas.

Methodology

Qualitative research can be defined as a form of interpretive techniques that try to explain, decode and translate the concepts and phenomena, rather than recording the frequency of a phenomena in society (Basis & Pollalis,2018). As qualitative methods are intended to achieve depth of understanding (Palinkas, 2015). Unlike quantitative research, which is based on quantifiable or numerical data qualitative research collect non numerical information about people's lives, thoughts and reactions to various circumstances. The research design used for this study is qualitative to gain in-depth understanding of

the sociocultural factors affecting girls' participation in STEM education. In the non-probability sampling technique further, the purposive sampling is used in the study. This involves identifying and selecting individuals that are especially knowledgeable about or experienced with a phenomenon of interest. The study used qualitative techniques that prioritize saturation, or getting a thorough understanding by sampling until no new significant information is found (Etikan, 2016). Furthermore, the sample size was not fixed in advance the researcher left it on the saturation point. The researcher collected the data and then realized that the participants were talking about same phenomena, so the researcher stopped the interviews. The total number of samples for the qualitative data was stood on 15 interviews. An extended one on one interview with a selected group of respondents is called in-depth interview, which is a qualitative research approach used to get feedback on a particular topic or situation you want to understand some one thoughts or opinions in depth interviews might be helpful (Boyce & Neale, 2006). In the present study the researcher collected relevant information through in-depth interviews with the girls enrolled in STEM fields in two universities (University of Swabi and Women University Swabi). Since the interview guide served as the research tool, the researcher obtained consent before beginning each interview with the subject about the audio recording of the interview by informing them that it would be difficult for the researcher to remember and capture all the conversation. Thematic analysis is used since it makes things easier because on already knows what they are looking for (St. Pierre, 2014). The process of exploring through a data set to find, examine, and report recurring patterns is known as thematic analysis (Braun and Clarke 2006). It involves looking for themes that can encapsulate the stories found in the data sets. It entails carefully reading and rereading the recorded data to identify themes (King,2004; Rice & Ezzy, 1999). (Braun & Clarke, 2006) outlined a six-step process for conducting thematic analysis, which helps researchers systematically work through the data and produce meaningful insights. Thematic analysis was employed to identify and interpret patterns in the qualitative data.

Results and Discussion

Gender stereotyping and societal beliefs

In interviews with respondents, it is explored that the academic and professional avenues that females can pursue are nevertheless shaped by ingrained social norms, cultural expectations, and gendered stereotypes, despite the fact that policies and educational reforms have made STEM areas more accessible to them. Girls are socialized to internalize what is deemed appropriate for their gender from an early age. Multiple interviews revealed that this conditioning affects their self-perceptions, career ambitions and subject preferences often without their conscious awareness (RPI 1,3,4,6).

As shared by the participants, media messaging, institutional prejudices, and familial advice are some of the ways that societal stereotype's function. According to the interview data, these prejudices actively create social, psychological and emotional obstacles that define who belong and who doesn't, rather than merely discouraging girls' from studying STEM. The result is a cycle in which society's preconceptions about girls limit their potential rather than their skills and abilities. Girls described multiple ways in which these stereotypes manifested themselves in their life during the interviews (RPI 2,3,6,7). A study by (Luo & So, 2023; Schmader, 2023) gender stereotypes pose serious obstacles that might impede students' aspirations, especially when it comes to careers in science.

Cultural norms and social control

In the interviews conducted, it is revealed that even when girls show a genuine interest in STEM, they frequently encounter subtle but powerful forms of opposition in the form of social control and cultural norms. In order to ensure that their choices and behavior align with traditional gender norms,

respondents explained how family, relatives and sometime teachers monitor and regulate them. According to the interviewees, this social control establishes invisible boundaries that girls are supposed to stay inside and inhibits divergence from "appropriate" feminine roles and subjects.

One respondent, from the department of Physics, shared during her interview:

"When I choose Physics as my field of study, my cousins said that this subject is not suitable for girls. This subject is studied in other cities, but in our village, there is no girl studying it, so they suggested that I choose another subject. They think that this subject is for boys. I am the first girl in my family to study Physics at my Bachelor level" (RPI5)

According to the interviewee, this rhetorical remark subtly undermines the participant's confidence and conveys the idea that females are naturally unsuited for particular academic pursuits.

Stereotypes about female intelligence

It is explored during the interviews, the persistent stereotype that girls are less intelligent in technical, logical or scientific reasoning is one of the most damaging obstacles to girls' involvement in STEM. As the respondents have repeatedly stated, this belief does not always manifest as direct discouragement but rather is ingrained in social norms, classroom dynamics and even internal self-doubt. According to the interview data, these stereotypes influence both internal and external perceptions, which makes many girls doubt their own intellectual worth even when they possess the aptitude and ambition (RPI 2,3,4,5). Due to the perception that STEM fields demand a particularly high level of intellectual ability, this gender brilliance stereotype may negatively impact women's prospects in these fields rather than other fields (Bian, Leslie, & Cimpian, 2018; Bian, Leslie, Murphy, et al., 2018; Ito & McPherson, 2018; Leslie, Cimpian, et al., 2015; Muradoglu et al., 2021).

One respondent stated:

"*People say girls are not intellectually sharp enough. Male are acceptable in science, technology, engineering and mathematics because all these departments are linked with male because male is intellectually sharp than female" (RPI7)*

Another respondent shared:

"People think these subjects are for boys. The role of the male is to do hard and technical work. Therefore, most of the time females do not go for STEM departments as much as male" (RPI2)

Family influences

It is explored in the interviews that for many females choosing to study STEM is a negotiated act influenced by family structures, expectations and values rather than just being a personal academic decision. Family was found to be one of the most important factors of girls' ability to seek and continue in STEM regardless of the presence or lack of support. During the interviews participants disclosed that their immediate family members particularly their parents often provided support by promoting education and approving of their daughters' interests. Other however spoke of opposition from extended family members that stemmed from conventional ideas about gender roles and suitable careers. A common feature in their narratives was the coexistence of this duality support or resistance within the same family or kinship network (RPI 2,3,5,15).

Family support for STEM engagement

According to a number of respondents, their families supported them in pursuing their interests in science and technology. According to the interviews, females felt free to pursue unconventional academic paths in homes where education was viewed as a gender-neutral value. It's interesting to note that a number of participants mentioned that their parents encouraged them to pursue a profession in STEM since they would be able to assist them in finding employment in the sector. It has been noted

that parents have supported and accompanied their children who decide to pursue careers in STEM. Accordingly, Coskun and Katitas (2021) pointed out that parental participation can be classified as either homebased or school based and can take many different forms. Strong feelings of self-worth, learning stimulation, and improved academic outcomes are all associated with high level of family and home participation (Alacam & Olgan, 2019; Marin & Bocos, 2017).

One respondent shared:

"My family has always believed in education. They never saw my interest in STEM as unusual and were very supportive from the start" (RPI6)

This insight, as discussed in her interview demonstrates how receiving approval from family members boosted her self-esteem and made pursuing technical subjects more common.

Another respondent shared:

"My parents always encouraged me to follow my interests. They saw my passion for technology and never held me back just because I'm a girl" (RPI8)

Family resistance to STEM engagement

Some participants talked about receiving support from their families, while others talked about encountering considerable opposition, especially when choosing technical fields that are viewed as "unfeminine". As discussed in the interviews this reluctance was frequently motivated by concerns about social norms or proper gender behavior rather than academic ability (RPI 5,6,7,8,9).

As one of the respondents shared:

"When I decided to choose Mathematics for my higher studies, my parents supported and encouraged me to follow my interest. But other family members didn't agree with my decision. They believed that girls should not go too far in education, especially in fields like mathematics, engineering and technology" (RPI11)

Her story throughout the interview represents a common experience; nuclear family support often coexisted with resistance from extended family members. Participants' responses reveal that at least on family member opposed their decision to major in STEM.

As one of the participant comments:

"When I decided to choose Electrical Engineering for my higher studies, my father asked: why did you choose Electrical Engineering you are a girl then I change my subject" (RPI10)

This narrative, during the interview highlights the gendered-coded nature of technical education in many families, with respondents expressing discouragement not because they lacked potential but because their decisions went against cultural expectations.

Nature of jobs and gendered career expectations in STEM

In the interviews, it was extensively stated that conceptions of the kind of professions connected with STEM degrees also play a role in girls' STEM selections, in addition to the subjects themselves. Respondents discussed that cultural perceptions of STEM occupations are masculine, physically demanding, or morally inappropriate for women sometimes deterred them even when they showed interest or talent in the field. According to the interviews, these job-based expectations have a significant impact on the academic paths and aspirations of girls (RPI 1,3,5,6,11). However, the STEM sector is still dominated by men women are less likely than men to choose STEM related educational programs, earn a STEM degree and work in STEM (Hill et al., 2010; Catalyst, 2018).

STEM careers as socially inappropriate for women

Interviews explored that many girls believed STEM careers, particularly those in engineering and IT did not fit with the expectations of society for female conduct (RPI 3,4,6,7,14).

One respondent commented during the interview:

"Girls are behind than boys in science, technology, engineering and mathematics subjects. The reason is very clear jobs associated with STEM subjects are not considered appropriate for girls. This discourages and prevent girls to study subjects that fall in the domain of STEM" (RPI8)

Another respondent reflected on this career-centered discouragement:

"The job market of STEM subjects compels girls to avoid these fields" (RPI11)

Preference for "safe" professions: Teaching and Medicine

Girls are more often pushed to choose jobs that are viewed as safe, respectable and consistent with cultural standards of femininity, as many participants have discussed. It was determined that teaching in particular was the default career path for women since it was viewed as socially acceptable and morally secure (RPI 2,3,5,7,8).

One participant shared:

"The family and females prefer teaching and medical professions. In science, engineering and technology, most jobs are field based. It could be one of the reasons that the females choose other fields compared to STEM fields" (RPI12)

Another respondent shared the same point:

"Women are not given a dominant position in our society and are often seen as needing assistance and protection from other. As a result, compared to pushing the girls to seek demanding or unusual careers like those in STEM disciplines, their families typically steer them toward occupations where they believe the girls would stay safe, respected and secure. Families prefer careers that are seen as safe and more socially acceptable for women because they believe that a girl priority should be stability and safety" (RPI1)

As discussed in the interviews, these comments highlight how job-related cultural norms shape academic participation as well as professional goals. Girls who select subjects that fit social norms even if they have no interest in those areas are rewarded for doing so.

Theme 5: Biological sciences versus Physical sciences, Engineering and Mathematics

During the interviews, it was explored how the distinction between the biological and physical sciences represents embedded gender norms and cultural expectations that influence female students' experiences in STEM in addition to academic specialization. According to respondents' women are increasingly participating in biological sciences including biotechnology, microbiology, and medicine, while physics, mathematics and engineering are still largely dominated by men. Biology is often represented as a people-centered, nurturing and socially significant subject in both homes and schools. According to the interviewees, these characteristics are consistent with traditional feminine values that are promoted in many societies. Whether subtly or sometimes explicitly, girls are told that they are naturally suited for jobs involving healing or providing care. Physical sciences such as physics, chemistry, astronomy, earth sciences or mechanical engineering on the other hand are typically classified as male domains due to their association with abstraction, technical skills and analytical reasoning (RPI 3,5,7,8,11).

As one of the respondents shared:

"Girls choose specific subjects in STEM like zoology, botany, microbiology, biotechnology because they feel more connected to helping others" (RPI2)

Conclusion

In conclusion, the study highlights that girls' participation in STEM is significantly shaped by enduring gender stereotypes, family expectations, and institutional practices that portray STEM as predominantly

male and culturally unsuitable for girls. These influences affect subject selection, undermine confidence, and steer many girls toward traditionally feminized STEM fields such as biology and medicine. Moreover, inadequate teaching methods and limited practical exposure further restrict participation. However, personal interest and supportive encouragement from teachers, family, or early experiences can inspire girls to continue in STEM. Ultimately, the findings underscore that boosting girls' involvement in STEM requires addressing and transforming cultural norms and gender biases within both society and the education system.

Recommendations

The policy makers should keep in mind that the initiatives to encourage females to participate in STEM education need to begin as early as secondary level of education.

The government should make policies for equal employment for females in STEM related careers.

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