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SPATIAL INEQUALITIES AND DEVELOPMENTAL BARRIERS TO WOMEN'S PARTICIPATION IN STEM HIGHER EDUCATION IN BANGLADESH: A GEOGRAPHICAL PERSPECTIVE

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Abstract

Women's participation in science, technology, engineering, and mathematics (STEM) remains disproportionately low in Bangladesh despite national commitments to gender equity and sustainable development. This study draws on primary survey data from female students, teachers, and parents in public and private universities, supplemented by data from secondary-level institutions in Gazipur district, to explore the barriers, motivations, and perceptions influencing women's representation in STEM. Findings reveal that motivational factors differ by institutional type: public university students emphasized employability (39%), while private university students highlighted personal interest (41%). Perceptions of underrepresentation also diverged, with public university students citing cultural barriers (62%) and private university students emphasizing gender stereotypes (68%).

Analysis of personal-level barriers showed higher constraints among public university stakeholders, including societal pressures (81%), gender bias (78%), and low confidence among teachers (78%). By contrast, private university respondents reported fewer challenges, though stereotypes remained significant. At the institutional level, deficits in laboratories and libraries, inadequate ICT facilities, overburdened teachers, and corruption in governance limited effective STEM learning. National statistics corroborated these findings, with only 79% of institutions employing computer teachers and 81% having internet facilities. Environmental vulnerabilities further exacerbated barriers, as 38% of schools were affected by floods and 11% by cyclones.

At the social and household level, entrenched gender ideologies, safety concerns, and child marriage continue to limit women's participation. Survey data revealed that 21% of students faced pressure for early marriage and 17% struggled to balance caregiving with academic responsibilities. These results align with literature documenting how patriarchal norms, gender-based violence, and early marriage constrain women's educational trajectories.

Overall, the study highlights that women's underrepresentation in STEM in Bangladesh is shaped by a nexus of cultural norms, institutional deficiencies, and structural vulnerabilities. Addressing these barriers requires multi-level interventions, including investment in resilient educational infrastructure, mentorship and role models for female students, gender-sensitive pedagogy, and policy reforms to reduce child marriage and strengthen family–school engagement.

Keywords: STEM education; gender bias; cultural barriers; institutional barriers; underrepresentation; social norms.

INTRODUCTION

Over the past two decades, Bangladesh has made substantial strides in improving girls' access to basic and secondary education. According to BANBEIS data, in 2023 the gross enrolment ratio (GER) for girls in tertiary education was about 16.51%, compared to 24.78% for boys under the same measure, though the overall GER (boys + girls) stood near 20.18% (BANBEIS, 2022). These gains, important as they are, have not yet translated into parity in STEM disciplines at the higher education or workforce level.

Globally, women make up about 33.3% of all researchers, based on data from the UNESCO Institute for Statistics covering 107 countries in 2015–2018 (UNESCO, 2021). In Bangladesh, the representation is significantly lower: women constitute only 14% of STEM professionals, according to a recent SheSTEM survey reported in 2024 (SheSTEM Survey, 2024). Similarly, a government spokesperson recently noted that only 14% of women are currently engaged in STEM education in Bangladesh (The Daily Star, 2024).

It is not just the overall STEM field that shows low female representation. In more technical or high-demand subject areas, the gap is more marked. For example, the SheSTEM survey found that women comprise about 28% of engineering graduates, and 22% in artificial intelligence (AI) fields nationally (SheSTEM Survey, 2024). Meanwhile, data reported by the LightCastle Partners indicates that among Bangladeshi students, women's participation in science departments is approximately 8.06%, engineering & technology about 1.46%, and in medicine just 0.03% (for the cohort referenced in 2019) – though such very low percentages may reflect particular institutional or sampling constraints (LightCastle Partners, 2025).

These shortfalls matter both morally and economically. STEM fields are core to innovation, technological advancement, and overall economic competitiveness. For countries like Bangladesh, which are aiming for rapid development, digitalization (e.g. ICT), industrialization, and participation in global value chains, harnessing full talent irrespective of gender is pivotal. A constrained female pipeline into STEM not only limits innovation but also perpetuates socioeconomic inequities(Fattah & Kabir, 2013; Malhotra & Elnakib, 2021).

Prior research in Bangladesh and neighboring South Asian countries has identified multiple layers of barrier. At the household and societal level, gendered expectations shape subject choices early: girls often face family pressure to take "safer" or socially acceptable fields (e.g., life sciences, humanities) rather than physics, engineering, or technology. Early marriage and caregiving responsibilities also act to truncate or divert educational trajectories. Public attitudes and norms around girls' mobility and safety (e.g. commuting, harassment) further restrict opportunities. Studies (e.g. the Brookings/Echidna policy report) note that rural girls, in particular, receive less investment in private tutoring and struggle more than urban peers in accessing well-resourced schools (Brookings/Echidna, 2019).

At the institutional level, deficits are stark. Many schools and colleges lack functioning laboratories, up-to-date equipment, continuous electricity or consistent Internet access — which are disproportionately worse in rural areas. Teaching practices lean heavily toward exam preparation rather than hands-on or experiential learning. Female students report lower self-confidence in physics and mathematics, which is linked to diminished exposure to experiments, role models, and supportive mentorship. Qualitative findings from recent field work echo these same themes of infrastructure gaps, teacher bias, locked or unusable lab facilities, and limited opportunities for female students to participate in STEM extra-curricular or mentoring programs.

Furthermore, external reports suggest that despite high overall tertiary enrolment for women in Bangladesh, the transition into STEM majors remains minimal. The SheSTEM survey's finding that only 14% of STEM professionals are women is indicative not only of enrollment gaps but of attrition along the educational and professional pipeline.

Given these facts, there is a pressing need for a study that not only quantifies the gender gaps in STEM participation but also examines how they arise — specifically, which factors at the individual, institutional, and societal levels act as the most prohibitive. Understanding these dynamics is essential to explain how gendered barriers manifest in higher education and to identify pathways for reform. This paper, therefore, draws on recent literature alongside primary data collected from female students, teachers, and parents in public and private universities in Bangladesh to address the barriers to women's participation in STEM higher education in Bangladesh and how do these barriers differ across institutional types and stakeholder groups.

By grounding analysis in both quantitative and qualitative evidence, the findings aim to inform actionable recommendations for universities, educational policy makers, civil society, and donors, in order that Bangladesh can more fully leverage its female talent in STEM for equity, innovation, and sustainable development.

MATERIALS AND METHODS

Research Design

This study adopted a mixed-methods design to comprehensively assess the status of female representation in STEM fields within higher education in Bangladesh. A combination of quantitative and qualitative approaches was employed to capture enrollment trends, institutional variations, and perceptions regarding STEM participation. Mixed methods were selected because they allow for both statistical generalization and in-depth exploration of socio-cultural dynamics influencing educational choices (Creswell & Plano Clark, 2018).

Study Population and Sampling

The study population comprised female students enrolled in STEM programs at tertiary-level institutions across Bangladesh. A purposive sampling technique was employed to ensure inclusion of students from both public and private universities, thereby capturing diversity in institutional contexts and socioeconomic backgrounds.

Primary data were collected from 200 female STEM students studying in 10 universities distributed across different regions of the country, ensuring geographical and institutional representation:

Dhaka University	Patuakhali University of Science & Technology
North South University	Khulna University
Southeast University	BRAC University
Jahangirnagar University	Shanto-Mariam University of Creative Technology
Begum Rokeya University (Rangpur)	Chattogram Veterinary and Animal Sciences University

Data Sources

Two types of data were utilized:

- **Secondary Data:** Statistical data were obtained from the Bangladesh Bureau of Educational Information and Statistics (BANBEIS, 2022), University Grants Commission (UGC) reports, and UNESCO databases. Additional references included the Annual Primary School Census and Bangladesh Education Statistics 2022, as well as comparative regional datasets from UNESCO (2017). Moreover, the findings from the earlier project phase on secondary-level STEM participation (uploaded report) were treated as a secondary source, providing background context on the school-to-university pipeline.
- **Primary Data:** New empirical data were generated at the university level through surveys, interviews, and focus group discussions (FGDs). These methods provided insights into enrollment challenges, motivational factors, and institutional support systems shaping women's STEM trajectories.

Data Collection Methods

- **Questionnaire Survey:** A structured questionnaire captured demographic information, academic background, motivations for choosing STEM, perceived barriers, and suggested interventions. The instrument was designed based on established studies on gender and STEM participation (Brotman & Mensah, 2008; UNESCO, 2017).
- **Interviews:** Semi-structured interviews with selected female students provided qualitative insights into personal experiences, aspirations, and challenges in pursuing STEM education.
- **Focus Group Discussions (FGDs):** Conducted with groups of 8–10 participants in each university to facilitate open dialogue about institutional practices, societal attitudes, and support mechanisms influencing female participation.

Ethical Considerations

All participants were informed about the objectives of the study, and voluntary participation was emphasized. Written informed consent was obtained prior to data collection. Confidentiality and anonymity were ensured by assigning codes to participants instead of real names. The study adhered to the ethical standards of social science research and followed the principles of the Declaration of Helsinki.

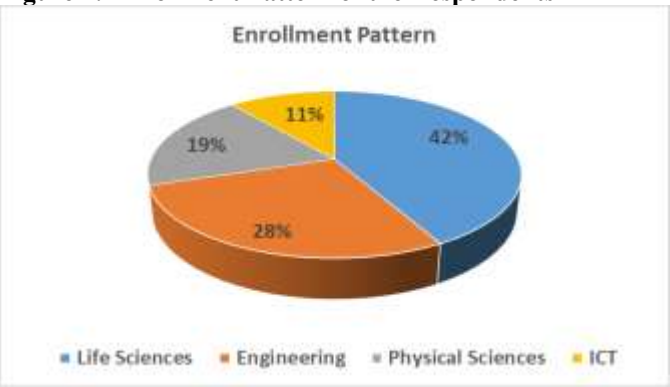
Data Analysis
Quantitative survey data were coded and analyzed using descriptive statistics (frequency distributions, percentages, and cross-tabulations) to identify patterns in enrollment, motivations, and perceptions. Qualitative data from interviews and FGDs were analyzed using thematic analysis, following Braun and Clarke's (2006) framework, to categorize responses into themes such as motivation, institutional barriers, gender stereotypes, and coping strategies (Braun & Clarke, 2006).
To strengthen reliability, triangulation of data sources (survey, interviews, FGDs, and secondary datasets) was applied. This mixed-methods approach ensured that statistical patterns were interpreted in light of students' lived experiences and broader institutional dynamics.

RESULTS AND DISCUSSION

Profile of Respondents
The primary dataset included 200 female students from 10 public and private universities across Bangladesh, representing disciplines in engineering, physical sciences, life sciences, and ICT. Respondents were 58% from public universities and 42% from private institutions, with a mean age of 21.4 years. About 65% were from middle-income families, 23% from low-income households, and 12% from higher-income groups. In addition, 25 STEM faculty members and 20 parents were interviewed to capture institutional and household perspectives.

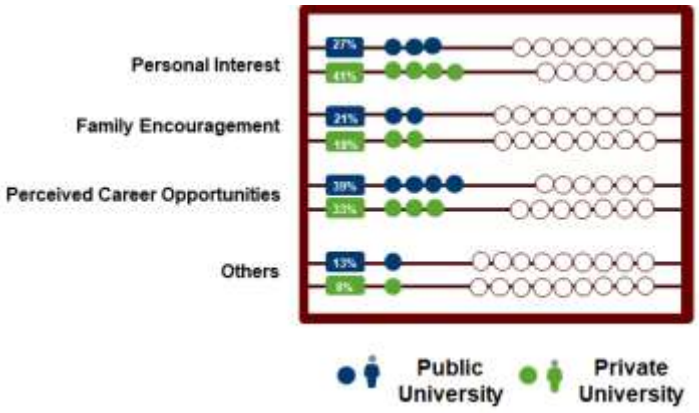
Enrollment Patterns
Although women now make up nearly half of tertiary enrolments in Bangladesh, their presence in STEM remains low. National estimates suggest that only 14% of women are engaged in STEM disciplines (The Daily Star, 2024). Within the study sample, most female students were enrolled in life sciences (42%), followed by engineering (28%), physical sciences (19%), and ICT (11%).

Figure 1: Enrollment Pattern of the Respondents



Motivational Factors for Choosing STEM
Analysis of motivational factors revealed notable differences between public and private university female students. Among public university respondents, 27% reported personal interest as the primary motivator, compared to 41% in private universities. Employability emerged as an equally important factor, cited by 39% of respondents in both public and private universities. Family encouragement was acknowledged by 21% of public university students and 18% of private university students.
A smaller proportion of students indicated that STEM was not their initial choice of study. Specifically, 13% of public university students and 8% of private university students reported selecting STEM due to external factors, such as family decision-making or limited seat availability in their preferred disciplines.

Figure 2: Motivational factors for choosing STEM by the respondents



Perceptions and Confidence in STEM

Confidence levels were uneven across subjects. While 61% of respondents felt confident in biology, only 28% expressed confidence in physics. Mathematics and ICT also scored low on self-efficacy. Teachers confirmed that physics was perceived as "a male subject," attributing gendered differences to rote pedagogy, limited lab exposure, and stereotypes.

Private coaching emerged as a critical factor: 46% of students reported needing tuition in mathematics and physics. Rural students were more dependent on coaching, highlighting inequities in secondary-school preparation. Parents confirmed that scarce family resources often prioritized sons over daughters for extra tutoring.

Institutional Level Barriers

Institutional barriers emerged as critical constraints to female students' participation in STEM education. Key challenges included the high cost of education, private tuition fees, poor institutional environments, institutional violence, lack of role models, and limited autonomy over educational and career choices. These constraints reflect systemic weaknesses across different tiers of the education system.

Laboratory facilities, an essential component of quality STEM education, were found to be inadequate in the surveyed schools. In a study of 30 secondary-level girls' schools in Gazipur district, 36% of laboratories were reported in poor condition, only 17% in good condition, while 20% of schools lacked laboratories altogether. Furthermore, even where laboratories existed, they were often underutilized, with equipment kept locked and unused for years. Similar deficits were observed in libraries, which limited students' access to reference materials and self-directed learning (Survey of Female Secondary School Students, Gazipur).

Structural weaknesses in the education system were also emphasized. Mulcahy (2015) observed that corruption and weak institutional governance exacerbate inequalities, with teachers often overburdened by teaching across multiple subjects (Mulcahy, 2015). Findings from the Gazipur survey also highlighted the rigidity of the examination system, where rote memorization is emphasized over critical and analytical skills, thereby reducing the effectiveness of STEM learning.

Environmental vulnerabilities further compounded these challenges. Disasters such as floods and cyclones frequently damage school infrastructure and disrupt educational activities. According to BANBEIS (2018), 38% of educational institutions were affected by floods and 11% by cyclones, underscoring the fragility of the education system in disaster-prone areas (BANBEIS, 2018). These recurring natural hazards not only reduce classroom time but also disproportionately affect girls, who are more likely to be withdrawn from school during crises.

National-level statistics further illustrate gaps in educational infrastructure. Although 92% of institutions had electricity connections by 2019, a significant proportion still lacked key STEM-related resources (BANBEIS, 2019). Only 87% of schools had computers, and fewer had trained computer teachers (79%). Internet connectivity was also limited, available in 80.8% of schools. These gaps in resources, alongside poor-quality facilities, directly undermine the effectiveness of STEM teaching and restrict opportunities for hands-on learning and digital literacy development.

In sum, institutional barriers in Bangladesh extend beyond financial burdens to encompass inadequate facilities, poor governance, lack of qualified teachers, and vulnerability to natural disasters. Together, these factors create systemic inequities that restrict female students' ability to pursue and thrive in STEM education.

Socio-Cultural and Household Constraints

Girls' education has long been recognized as a cornerstone of sustainable social development and skilled human resource formation. However, entrenched patriarchal gender ideologies continue to constrain women's lives in Bangladesh, particularly in the context of STEM. These fields remain male-dominated, reinforced by perceptions of men's "natural" aptitude, social exclusion, and persistent stereotypes that portray technology as a male domain. Such attitudes are more pronounced in rural and remote areas, rendering STEM careers unfamiliar or unattractive to many young women. Cultural and social barriers also keep girls out of school altogether, as parents often cite concerns about gender-based violence and harassment, with reports highlighting fear of sexual violence in rural Bangladesh (Fattah and Kabir, 2013). The persistence of child marriage further compounds these constraints: Bangladesh ranks fourth globally, with 19.8% of girls married before the age of 15 and 60% before 18 (Malhotra & Elnakib, 2021). Despite government pledges to eradicate child marriage by 2041, progress remains inconsistent and policies contradictory.

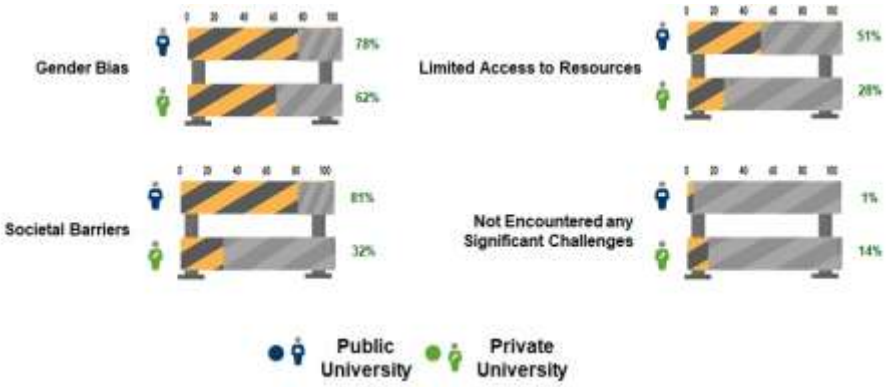
Parental and student narratives collected in this study further illustrate how household and social expectations shape academic choices. Parents frequently encouraged daughters to pursue "acceptable" careers such as medicine or teaching, while discouraging engineering or ICT due to perceived gender norms and safety concerns. Harassment during commuting, fieldwork, or late-hour lab work was reported as a deterrent, limiting opportunities for hands-on learning and internships. Additionally, 21% of surveyed students reported facing pressure for early marriage, while 17% indicated that caregiving responsibilities constrained their academic performance. These findings mirror earlier data from the secondary school level, where chronic absenteeism and domestic obligations disproportionately affected female students (Nath & Sylva, 2007). Together, these constraints illustrate how social norms, household responsibilities, and structural vulnerabilities intersect to restrict girls' access to and persistence in STEM education and careers.

Perceptions from Primary Data

Analysis of primary data revealed that students, teachers, and parents identified a range of personal, societal and institutional level barriers to female participation in STEM programs. Students were allowed to select multiple options but teachers and parents selected single option, and the findings varied between public and private universities.

Students: Among female students in public universities, the most frequently reported barriers were societal pressures (81%), gender bias (78%), and limited access to resources (51%). Only 1% of respondents indicated that they had not encountered any significant challenges. In contrast, female students in private universities reported lower levels of challenges: 62% cited gender bias, 32% societal barriers, and 28% limited access to resources, while 14% reported no significant challenges.

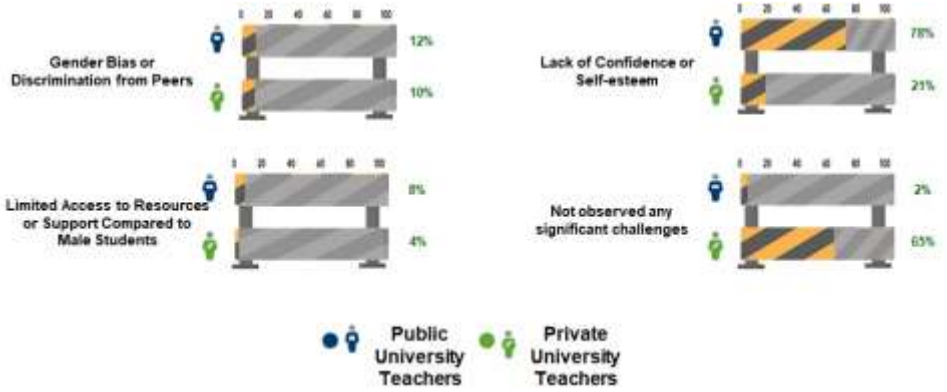
Figure 3: Students' perception on barriers to STEM education



Teachers: Public university female teachers predominantly highlighted issues of low self-confidence or self-esteem (78%), with smaller proportions citing gender bias (12%) and limited access to resources (8%). Only 2% reported no significant barriers. In private universities, however, the pattern was reversed: a majority

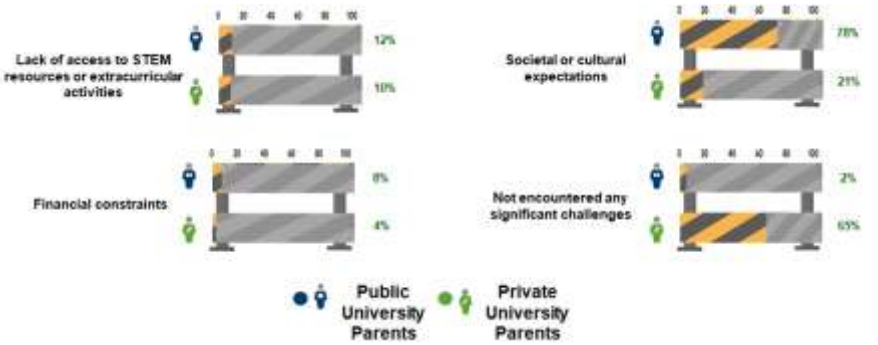
(65%) reported facing no significant challenges, while a smaller proportion cited lack of confidence (21%), gender bias (10%), and limited access to resources (4%).

Figure 4: Teachers' perception on barriers to STEM education



Parents: Parents of female students also emphasized household and cultural influences. At public universities, 68% cited societal or cultural norms, 18% financial constraints, and 12% lack of access to STEM resources, while only 2% reported no significant challenges. Conversely, among private university parents, 55% indicated no significant challenges, with 30% citing social or cultural norms, 10% lack of STEM resources, and 5% financial constraints.

Figure 5: Parents' perception on barriers to STEM education



This analysis demonstrates that public university stakeholders reported far higher levels of personal barriers compared to their private university counterparts. While societal and cultural norms, gender bias, and resource limitations were predominant concerns in public universities, a considerable proportion of private university respondents particularly teachers and parents indicated relatively fewer personal-level challenges.

Students' Perceptions on Underrepresentation of Women in STEM

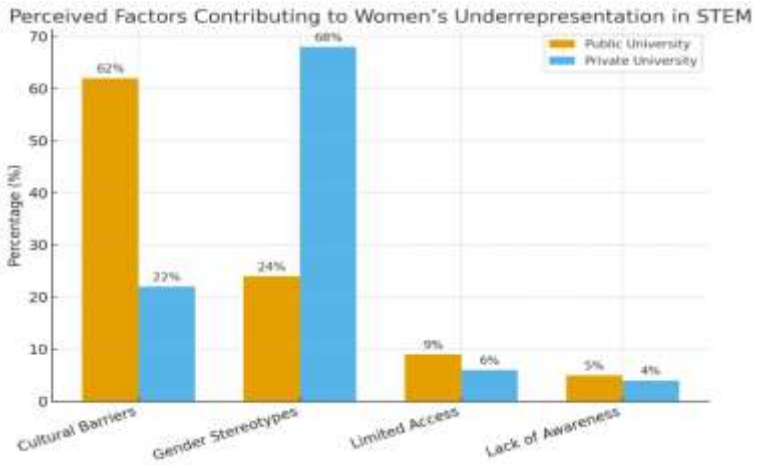
Students were asked what factors they believed contributed to the underrepresentation of women in STEM fields in Bangladesh. Their responses revealed significant differences in perceptions between public and private university female students.

Among public university students, the majority (62%) identified cultural barriers as the most significant factor. Other contributing factors included gender stereotypes (24%), limited access to resources (9%), and lack of awareness (5%).

In contrast, private university students emphasized gender stereotypes, with 68% citing this as the primary reason for women's underrepresentation in STEM. Cultural barriers were less frequently reported (22%), while limited access (6%) and lack of awareness (4%) were mentioned by a smaller proportion of students.

Overall, these findings suggest that while public university students view structural and cultural barriers as the dominant challenge, private university students emphasize attitudinal and stereotype-based barriers. This divergence may reflect differences in exposure, institutional environments, and social contexts between the two groups.

Figure 6: Perceived factors contributing to the underrepresentation of women in STEM fields



DISCUSSION

This study explored the multi-layered barriers and perceptions that shape women's participation in STEM education in Bangladesh, integrating perspectives from students, teachers, and parents across both public and private universities. The findings underscore that women's underrepresentation in STEM is not the outcome of a single factor, but rather the intersection of personal, social, institutional, and structural challenges.

Motivational Factors and Perceptions

The results indicate differences in motivational drivers across public and private university students. While public university students highlighted employability (39%) as a major factor, private university students emphasized personal interest (41%) as their primary motivator. Family encouragement was important for both groups, albeit at lower rates (21% public; 18% private). Notably, a proportion of students acknowledged that STEM was not their first choice, with 13% of public and 8% of private university students citing family decision-making and seat availability as influencing their enrollment. These findings resonate with prior research showing that women's entry into STEM often reflects a negotiation between personal aspiration and family or societal expectations (Sikdar & Mitra, 2018).

Perceptions of underrepresentation also diverged across contexts. Public university students attributed women's absence in STEM largely to cultural barriers (62%), while private university students stressed gender stereotypes (68%). This contrast may reflect differences in institutional environment and exposure: students in public universities are more directly constrained by structural and societal barriers, whereas students in private universities confront attitudinal challenges within peer and institutional networks. Prior studies have similarly emphasized that cultural norms and stereotypes perpetuate STEM as a male domain in South Asia (UNESCO, 2017).

Personal and Household Barriers

The primary dataset revealed strong evidence of personal-level constraints. Among public university students, 81% cited societal barriers and 78% gender bias, compared to lower levels in private universities. Teachers in public universities were more likely to report low confidence and self-esteem (78%), whereas private university teachers reported fewer challenges overall (65% reported none). Parents in public universities emphasized cultural norms (68%) and financial constraints (18%), while over half of private university parents reported no significant challenges. These findings echo literature on entrenched gender ideologies in Bangladesh, where patriarchal expectations and early marriage disproportionately affect girls' educational continuity (Fattah & Kabir, 2013; Malhotra & Elnakib, 2021).

Household responsibilities further complicate participation. In this study, 21% of students reported pressure for early marriage, and 17% reported caregiving responsibilities interfering with academic work. These findings are consistent with secondary-level research, where chronic absenteeism and dropout among girls were linked to domestic workloads and socio-cultural practices (Nath & Sylva, 2007).

Institutional Barriers

Institutional-level challenges were striking, particularly at the secondary level. The Gazipur survey revealed that 36% of laboratories were in poor condition, 20% of schools had no laboratories, and even existing facilities were often unused. Libraries reflected similar deficits. These infrastructural weaknesses undermine opportunities for experiential STEM learning. At the national level, BANBEIS (2019) reported that only 79% of schools had computer teachers and 81% had internet connectivity, far below the requirements for modern STEM education. Such deficiencies reflect not only inadequate investment but also poor resource utilization and governance, aligning with Mulcahy's (2015) argument that corruption and weak institutional systems are major barriers to equity in education.

Environmental vulnerabilities further exacerbate institutional challenges. BANBEIS (2018) reported that 38% of institutions were affected by floods and 11% by cyclones, underscoring the fragility of educational infrastructure in disaster-prone Bangladesh. Given that STEM education depends heavily on laboratory and ICT resources, these disruptions disproportionately impede skill-building opportunities.

Broader Implications

The convergence of personal, social, and institutional barriers highlights how structural inequalities perpetuate women's underrepresentation in STEM. While private universities appear to offer more supportive environments, with fewer reported challenges, the persistence of gender stereotypes underscores that attitudinal barriers remain. Conversely, public universities face stronger constraints from societal norms, resource shortages, and institutional weaknesses, which collectively discourage women from fully engaging in STEM.

Addressing these challenges requires multi-level interventions. At the personal and household level, strategies must include awareness campaigns to challenge gender stereotypes, initiatives to reduce child marriage, and support systems for balancing domestic responsibilities. At the institutional level, urgent reforms are needed to improve laboratory and ICT facilities, ensure disaster-resilient infrastructure, and create equitable teacher-student support systems. At the societal level, sustained efforts to shift cultural narratives around STEM as a male domain are critical. International experiences show that mentorship programs, visible female role models, and gender-sensitive pedagogy can improve women's persistence in STEM fields (Dasgupta & Stout, 2014).

In sum, this research illustrates that women's participation in STEM in Bangladesh is shaped by a nexus of barriers ranging from the household to the institutional environment. While incremental improvements are visible, particularly in private universities, entrenched gender ideologies and weak institutional systems continue to limit progress. Future interventions must adopt a holistic approach, addressing both structural inequalities and cultural norms, to build an inclusive STEM pipeline that can contribute meaningfully to the nation's socio-economic development.

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