# STEM Education in Pakistan: A Gender-Based Perspective

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## Abstract

*In Pakistan, women are significantly underrepresented in Science, Technology, Engineering, and Mathematics (STEM) fields, despite their crucial role in national development. This study investigates the factors influencing women's decisions to pursue STEM education at universities in Karachi, addressing disparities and suggestions to reduce gender equality. Employing a quantitative methodology, the research surveyed 80 female STEM students from public and private universities in Karachi using stratified random sampling. Data was collected focusing on reasons for choosing STEM, support systems, and challenges. The findings reveal that while a majority of female students (69%) choose STEM disciplines due to personal interest and intellectual growth, external influences such as parental pressure (14%) and cultural expectations persist. Fathers (34%) and teachers are primary sources of encouragement. Key challenges include a significant lack of awareness and access to mentorship programs (84% were unaware), pervasive gender bias (39% identified it as a top employment barrier), and familial expectations prioritizing early marriage. The study concludes that enhanced support systems, targeted awareness initiatives for parents, robust mentorship programs, and inclusive policy interventions are urgently needed to advance gender equality in STEM education and careers in Pakistan.*

Key Words**:** *Women in STEM, gender equality, Mentorship, Family support, Culture, Social barriers.*

## Introduction

In many countries in South Asia, and in the UK, women's participation in higher education (HE) has equaled or surpassed men's in recent years. However, this trend is not reflected in STEM (Science, Technology, Engineering and Mathematics) subjects. Women are therefore less likely to pursue careers in STEM subjects arguably this creates an endless cycle as there is therefore a dearth of role models for young women interested in science, technology, engineering and Math. Women fulfill diverse roles in society- as mothers, daughters, professionals, and leaders. Although motherhood, a single element of womanhood, symbolizes care and duty across cultures, yet the concept encompasses a wide range of experiences, identities, and manifestations shaped by cultural, societal, and individual factors. To fully empower women in these diverse roles and to unlock their potential as societal contributors, the prioritization of women's education is paramount. Universally recognized as a fundamental human right and a key driver of socioeconomic development, education is a foundational pillar for achieving the Sustainable Development Goals (SDGs). However, in many parts of the world, including Pakistan, women are often deprived of this basic right. According to the Pakistan Education Statistics Report, the literacy rate for women is 59%, significantly lower than the 71% for men, a disparity driven by cultural norms, poverty, and a lack of educational facilities (Askari et al., 2023).

The 21st century, an era defined by technology, demands knowledge, understanding, and digital proficiency. According to OECD (2014), the fields of science, technology, engineering, and mathematics (STEM) emerged as critical drivers of innovation, economic growth, and societal progress .Globally, nations prioritized STEM education; such as the United States through its Next Generation Science Standards (NGSS leads states 2013), the UK through integrated policies, and Germany via its National STEM Forum (Ahmed et al.,2020) paved a way to reduce the gender gap in STEM education. The phenomenon also called researchers to explore the key factors that create this gender gap and suggestions to overcome the challenges (Card & Payne, 20210. Similarly, Pakistan, recognizing STEM's pivotal role, has initiated programs through the Pakistan Science Foundation (PSF) (Kang, NH, 2019) and the Higher Education Commission (HEC) to foster innovation and economic growth (Javed, T. 2021).

Despite this global recognition and national efforts, women remain severely underrepresented in STEM, particularly in countries like Pakistan where societal norms and cultural barriers pose significant challenges. In Pakistan, while tertiary enrollment rates have nearly reached gender parity, this trend is not reflected in STEM subjects. Girls comprise 57% of all out-of-school children, and women complete far fewer PhDs than men, leading to their serious underrepresentation in STEM careers (S. Hollows, et al., 2020). Additionally, World Economic Forum Global Gender Report (2024) highlights major enrolment gaps across various educational stages in Pakistan.

This research problem is situated at the intersection of three critical Sustainable Development Goals: SDG 4 (Quality Education), SDG 5 (Gender Equality), and SDG 8 (Decent Work and Economic Growth) (United Nations, 2015). Equal access for females to STEM education is not

merely a matter of equity but a strategic imperative for national development. Scientifically, it fosters diverse perspectives and innovative solutions; socially, it ensures equal skill development and reduces bias in research and technology. **(**Benmassoud, Jihane & Bouchara, Aicha. (2023).

Although several actions and programs have been put in place to ensure men and women receive equal opportunities and treatment in education, these initiatives have not yet achieved a balanced participation rate between genders in fields like STEM (Science, Technology, Engineering, and Mathematic. the participation of women in STEM fields in Pakistan remains significantly lower than that of men. This research will investigate how many women are currently enrolled in STEM, why they choose these subjects, and how family and societal attitudes influence their decisions. It will also assess the resources and support available to them, the role of parental support, and the obstacles they face in advancing their careers in STEM. Understanding these issues is crucial for developing strategies to increase women's participation in STEM, which will help achieve gender equality and support national development. Therefore, this study, seeks to investigate the complex dynamics influencing female participation in STEM in Karachi. It explores the current enrollment trends, the powerful influence of family and societal attitudes, the availability of resources and support systems, and the formidable barriers to career progression. By providing a comprehensive understanding of these issues, this research aims to inform effective strategies and policies to increase women's participation in STEM, thereby contributing to the achievement of gender equality and sustainable national development.

## Literature Review

### An overview of STEM History

The roots of STEM (Science, Technology, Engineering, and Mathematics) are deeply embedded in human history, with foundational contributions from figures like Archimedes in Greece and Al-Khwarizmi during the Islamic Golden Age (Freeman, K. 2021). The recent formalization of STEM as a cohesive educational concept, however, is a 20th-century development, popularized by the U.S. National Science Foundation (NSF) to emphasize the interconnected nature of these fields in driving innovation and solving complex global challenges (Breiner, et al.,2012) .Despite its recognized importance for economic competitiveness and societal progress, a significant and persistent gender gap plagues STEM fields worldwide. UNESCO data indicates that only 30% of female students select STEM-related fields in higher education, and women represent just 35% of all STEM students globally (Benmassoud, et al., 2023)**.**

### Theoretical Frameworks: Understanding the Roots of Inequality

The inequalities and disparities women and girls face exist due to many reasons. To understand the underpinnings of the roots of discrimination the study takes insights from gender socialization theory, feminist theory and social learning theory.

**Gender Socialization Theory:** This theory posits that from a young age; societal expectations and cultural norms actively shape gender roles. In the context of STEM, these norms often stereotype these fields as intellectually demanding, "male-dominated" domains, thereby discouraging girls'

initial interest and participation. This creates a social environment where STEM is perceived as an unnatural or challenging path for women (S. Hollows, et al., 2020).

**Feminist Theory:** Providing a critical lens, feminist theory challenges the patriarchal structures that systematically marginalize women in educational and professional spheres. It advocates for research and initiatives that not only highlight these inequalities but also actively deconstruct gender biases and empower women to claim their space in traditionally male-dominated fields like STEM.

**Social Learning Theory:** This theory highlights the importance of observation and modeling in learning behaviors and forming aspirations. The presence of visible female role models, mentors, and leaders in STEM provides a powerful counter-narrative to stereotypes, demonstrating to young women that success in these fields is attainable and can influence their own career choices (Dewa, Hansi, Raveena, Senevirathne, 2024).

**Female representation in STEM Education; Regional and International Trends**

To understand the dynamics of the female participation in STEM education, it is important to explore the regional trends. despite possessing one of the world's most rigorous and competitive education systems that heavily emphasizes STEM, South Korea continues to struggle with female underrepresentation, particularly in engineering (Hwang, Soonhee,2024)**.** This is largely attributed to deeply entrenched gender biases rooted in Confucian values. Initiatives like the "Women in Engineering" course have been introduced specifically to address the high dropout rates and low employment levels among women in these fields (Jong-Tae Youn, Song-Ah Choi , 2015).

Similarly, in China**,** through strong policy guarantees of equal educational rights and a national strategic focus on industrial modernization, China has dramatically increased female participation in higher education. Women now not only excel in STEM but even outnumber men in some undergraduate programs. This demonstrates the potential of top-down policy interventions to create systemic change (Yang, Jiale & Shen, Wenqin, 2020).

Sri Lanka is often recognized for its gender-equal educational opportunities at the entry level, Sri Lanka sees females constituting approximately 49% of STEM undergraduates. However, significant disparities persist within specific sub-fields like engineering, influenced by persistent societal stereotypes that perceive such technical careers as male domains (UN Women Asia and the Pacific (2024).

In India's STEM education is focused on an integrated, hands-on approach that extends from primary to higher education, promoting STEM learning through programs like the Atal Tinkering Labs, which provide experiences in science and technology for students, guided by the National Education Policy 2020 (Aditi 2024). With only 35% of female STEM students, a figure lower than many regional counterparts, this disparity is driven by deep-rooted challenges including gender bias, stereotypes, a lack of female role models, and socio-cultural factors (UNESCO, 2017). While the government has launched programs like "Beti Bachao, Beti Padhao" and "Udaan" to promote gender diversity, with grassroots efforts from educators, parents, and non-profits. While these

collective actions to dismantle socio-cultural barriers, enhance role model visibility so that girl can seek stem education and career (Samad, Abdul, 2024)

On the contrary, in Pakistan, women constitute approximately 36% of the scientific workforce, a figure that, while low, surpasses that of some regional neighbors. This indicates a potential for growth that is currently stifled by multifaceted barriers, as illuminated by a growing body of national research (Pakistan Council for science and technology, 2022). There are many reasons identified for low female participation in STEM fields.

**Socialization and cultural attitudes**

Research underscores persistent socio-economic and institutional barriers to gender equity in education. Empirical evidence suggest that female enrollment in STEM at the tertiary level is significantly hindered by financial constraints, societal perceptions, and safety concerns, necessitating robust institutional support and policy interventions (Ahmed et al., 2023). O'Connell and McKinnon (2021) explore the barriers that women face in advancing their careers within STEM academia. These barriers include entrenched biases, stereotypes, double standards, bullying, harassment, and the challenge of balancing career and family. These challenges persist across countries, disciplines, and career stages, and they hinder women's progress in academic STEM fields. Addressing these issues requires a reshaping of gendered norms to promote equity and inclusion in STEM academia.

This underrepresentation begins early, where girls are often subtly or overtly diverted away from science and math in schools, creating a "leaky pipeline" that continues to deplete female talent through higher education and into professional careers (Funk, et al., 2018). Research of Khairpur, Sindh, identified societal norms, conservative family expectations, and safety concerns as critical factors deterring girls' education, particularly in fields requiring mobility or perceived as non-traditional. These patriarchal structures, combined with widespread economic constraints, severely limit opportunities. The financial burden is acute, with this study's data revealing that 52% of surveyed students found their university fees unaffordable (Muhammad et al., 2019).

This aligns with findings from Pakistan, where education is identified as a critical driver for women's economic empowerment, benefiting broader societal development (Umar et al., 2021). Furthermore, gender bias remains a critical impediment. A study by Pusey (2020) highlights that implicit biases and stereotyping create unwelcoming environments, contributing to the underrepresentation of women in STEM fields; proposed solutions include mentorship and training educators to foster inclusivity.

Recent research by Mujtaba et al. (2023) directly highlights the critical challenges of "low self-confidence, lack of academic support, and gender disparities as key barriers for women in STEM, especially engineering." Their work urges the "creation of supportive learning environments and targeted interventions" to help female students succeed, pointing to a need for psychological and pedagogical support within academic institutions. This is compounded by the findings of Mujtaba et al. (2023), who identify how "overlapping factors like class, ethnicity, and disability impact

women in STEM," urging the adoption of "inclusive, identity-aware policies." This intersectional perspective is crucial, revealing that the experience of a woman in STEM is not monolithic but is shaped by the complex interplay of her socioeconomic background, ethnic identity, and physical ability.

Pervasive implicit biases, micro-aggressions, and stereotyping create an unwelcoming environment that erodes confidence. Kirkland and Kolski (2024) confirm that "societal expectations and stereotypes hinder girls' participation in STEM," and they specifically "urge educator training to foster inclusive learning environments." This places a significant onus on teachers and professors to become agents of change by adopting gender-sensitive pedagogical practices. Furthermore, Warsito et al. (2023) identify "stereotypes and lack of role models" as primary factors limiting girls' STEM engagement, suggesting "mentorship, inclusive teaching, and career guidance as solutions."

**Institutional barriers**

Gender inequalities usually stem from institutionalized structures of culture and society. Familial impact and the influence of family unit is profound in Pakistani society. Hence, the role of family in girl education gained attention at primary, secondary and tertiary levels. Shen (2024) provides a critical insight into the post-graduation phase, finding that "spousal support and family dynamics significantly influence women's ability to stay in STEM careers, highlighting the role of shared goals." This suggests that familial support must be sustained beyond education and into professional life to combat the "leaky pipeline."

Furthermore, a glaring deficit exists in structured mentorship and career guidance for students in general and females in particular. Research by Wolf & Brenning (2023) champions "mentorship as key to improving female retention in STEM, emphasizing confidence-building and recommending evidence-based frameworks to assess long-term impact." This study's data starkly confirms this gap, showing that 84% of respondents were unaware of mentorship programs, and 62% were unsure if career guidance for women in STEM was available at their institution. This represents a major systemic failure.

Wolf and Brenning (2023) evaluate the effectiveness of mentorship programs for women in STEM. By developing an evidence-based framework for assessment, their study addresses the challenges female students face, such as stereotypes and lack of role models. The study proposes a flexible evaluation design that focuses on both short-term outcomes and long-term impacts, aiming to improve the effectiveness of mentorship programs in enhancing academic and professional outcomes for women in STEM.

Julia, Griselda Cerón, et al., (2024) highlight the importance of mentorship programs in fostering gender equality and inclusion in STEM. These programs aim to enhance the skills and certifications of both mentors and mentees, thus improving professional growth and increasing educational and employment opportunities for women in STEM. With women representing only

30% of the global STEM workforce, mentorship becomes a crucial strategy for promoting equality and supporting women's participation and success in STEM fields.

Ali et al. (2023) review emphasizes the necessity of developing inclusive strategies that address not only academic support for female students but also broader societal perceptions. This dual approach could foster a more enabling environment for women in STEM fields. A combination of "cultural resistance, lack of resources, and weak family support" identified as core impediments Qaisar (2024), there is a need for solutions that are consequently multi-pronged, calling for scholarships, awareness, and gender-sensitive education policies" to create a more enabling ecosystem. To address this research gap, it is important to understand the factors influencing women's decisions to pursue STEM education in Pakistan, including family attitudes, societal perceptions, the availability and accessibility of resources and support systems, as well as pathways and barriers to career progression for women in STEM fields. To further expand the scope of our understanding about gender inequalities in the STEM field in Pakistan, the study explores it by following these objectives.

**Objectives of the Study**

1. To analyze the factors influencing women's decision to pursue STEM subject at the higher level of education in Pakistan.
2. To explore the role of family attitudes and societal perceptions in shaping Pakistani women's interest and participation in STEM education.
3. To investigate the availability and accessibility of resources and support systems for women pursuing STEM education in Pakistan, including mentorship programs and career guidance.
4. To investigate the impact of parental support and encouragement on Pakistani women's pursuit of STEM education.
5. To explore the pathways and barriers to career progression for women graduates in STEM fields in Pakistan, including factors influencing employment opportunities and advancement prospects

## Research Methodology

According to Martyn Shuttle (2008), definition of research, the gathering of facts, data, and information for the goal of improving understanding qualifies as research in every sense of the word.

This study adopted a quantitative research design, employing a survey method to collect measurable data from female STEM students in Karachi. The research paradigm was rooted in both social research and a feminist research perspective, aiming to systematically understand the societal barriers faced by women and to make their experiences visible.

The population comprised female students enrolled in STEM disciplines at higher education institutions in Karachi South. Karachi South hosts several notable universities offering STEM programs, predominantly in the private sector. Institutions such as NED University of Engineering

and Technology and Aga Khan University are pivotal in providing quality education in engineering and health sciences respectively. Public universities like the University of Karachi also contribute significantly to STEM education but face challenges related to funding and resources compared to their private counterparts. The increasing demand for skilled professionals in STEM fields is reflected in the growing enrollment rates at these institutions, which cater to the aspirations of a rapidly urbanizing and diverse population seeking advanced educational opportunities in technology and science-related disciplines. In Karachi (Karachi south) , University of Karachi, which serves around 24,000 students and offers a wide range of programs across various faculties, including engineering and sciences.[i] Private universities like the National University of Computer and Emerging Sciences (NUCES-FAST) and Sir Syed University of Engineering and Technology (SSUET) and other also play significant roles in providing STEM education, focusing on disciplines such as computer science and engineering. [ii] [iii] [iv] In this research I have selected institutions of Karachi South which includes University of Karachi, NED University of Engineering and Technology, Dawood University of Engineering and Technology, Baharia University.

A probability sampling technique, specifically stratified random sampling, was used to ensure representation across various universities and disciplines. The final sample consisted of 80 female students selected proportionally from both public and private institutions.

A structured interview schedule comprising 45 questions (both close-ended and open-ended) was developed in English. The questionnaire was pre-tested to identify and rectify ambiguities. Data was collected through direct surveys, with each interview lasting approximately 10-15 minutes.

The collected data was processed and analyzed using descriptive statistics. The findings were represented in the form of tables and graphs. Furthermore, chi-square tests were employed to test the study's hypotheses, providing a statistical basis for the conclusions drawn.

## Discussion and Analysis

Table 1

| Why did you select this field of study? | Frequency | Percentage |
|---|---|---|
| Due to my interest and passion | 55 | 69% |
| Parents pressure / will | 11 | 14% |
| To get a good salary job | 2 | 2% |
| To avoid chemistry | 1 | 1% |
| Senior suggested | 1 | 1% |
| By chance | 3 | 4% |
| N-A | 7 | 9% |
| Total | 80 | 100% |

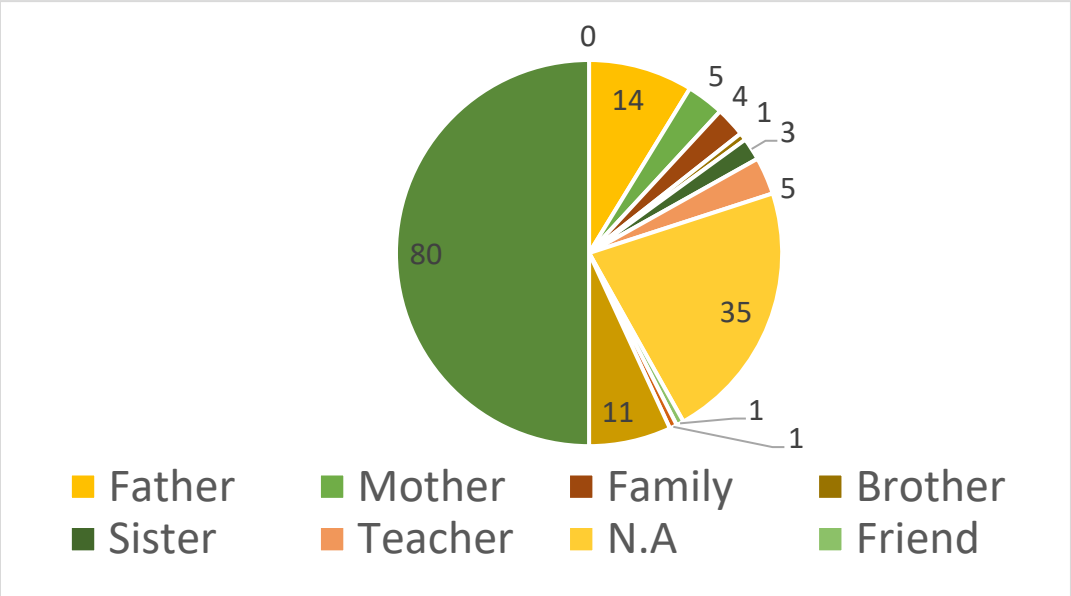
The data reveals that the majority 69% of respondents chose their field of study based on personal interest and passion, highlighting intrinsic motivation as the primary driver. Parental pressure influenced 14% of participants, while 2% were motivated by potential financial rewards. Smaller percentages cited avoidance of chemistry 1%, senior suggestions 1%, or chance 4% as their reasons. Additionally, 9% did not provide a specific reason. This indicates that while personal interest is the dominant factor, external influences and situational factors also play a role in academic decision-making.

Table 2

| What are your future plans for higher studies in STEM field? | Frequency | Percentage |
|---|---|---|
| Master | 54 | 67% |
| I will do job to support my family | 3 | 4% |
| NA | 23 | 29% |
| Total | 80 | 100% |

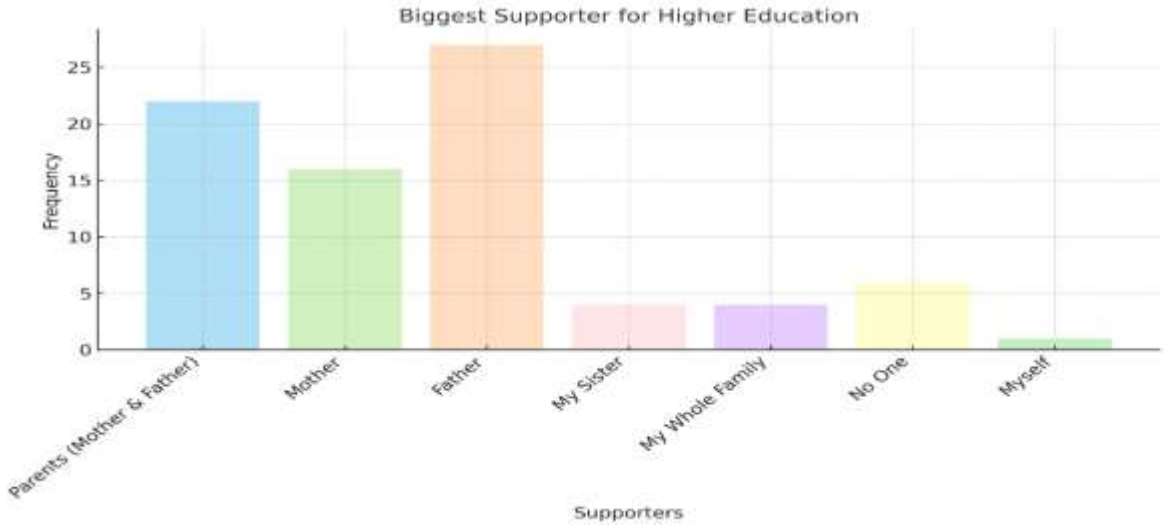
The data indicates that a majority of female students enrolled in STEM education at the university have plans to pursue higher studies, with 67% (54 students) aiming for a Master's degree. A small percentage, 4% (3 students), do not plan to pursue further education and instead intend to enter the workforce to support their families. Additionally, 29% (23 students) did not specify their plans (NA). This suggests that while most students are focused on advancing their education in the STEM field, a notable portion remains undecided or may have other priorities.

*Figure 1*



The data shows the sources of inspiration for female students enrolled in STEM education at the university. A significant portion, 44% (35 students), did not specify their inspiration (N.A.). Among those who provided a response, 18% (14 students) are inspired by their father, making him the most common source of motivation. Mothers are the inspiration for 6% (5 students), while teachers also serve as role models for another 6% (5 students). Other family members, such as siblings, inspire smaller groups: 4% (3 students) are inspired by their sister, and 1% (1 student) by their brother. Additionally, 14% (11 students) mentioned "other" sources of inspiration. This highlights the diversity in sources of inspiration, with family being the most prominent, though a large number of students remain unsure or did not specify.

*Figure 2*




The data shows the sources of support for female students pursuing higher education in STEM. The largest group, 34% (27 students), identifies their father as their biggest supporter, followed by 28% (22 students) who are supported by both parents. Mother alone is the biggest supporter for 20% (16 students). A smaller number of students, 5% (4 students each), are supported by their sister or their entire family. However, 7% (6 students) reported having no support, and just 1% (1 student) consider themselves their biggest supporter. This highlights that parental support, particularly from fathers, plays a significant role in students' pursuit of higher education, although there are also students who face challenges in receiving support.

Table 3

| What are the biggest challenges facing Pakistani women in stem field? | **Frequency** | **Percentage** |
|---|---|---|

| | | |
|---|---|---|
| Lack of families support | 17 | 21% |
| Limited access to resources and funding | 9 | 11% |
| Gender bias and discrimination | 17 | 21% |
| Lack of knowledge or interest of field | 7 | 9% |
| All of above | 30 | 38% |
| Total | 80 | 100% |

The data reveals the biggest challenges faced by Pakistani women in the STEM field. A significant portion, 38% (30 students), reports experiencing all of the listed challenges. Both lack of family support and gender bias and discrimination are cited by 21% (17 students) each, indicating that these social and cultural factors are significant barriers. Limited access to resources and funding is noted by 11% (9 students), pointing to financial constraints as a challenge. Additionally, 9% (7 students) mention a lack of knowledge or interest in the field as a challenge. These findings emphasize that a combination of societal, financial, and informational barriers affects women in the STEM field in Pakistan.

Table 4

| Have you participated in any mentorship programs in STEM | Frequency | Percentage |
|---|---|---|
| Yes | 11 | 14% |
| No | 69 | 86% |
| Total | 80 | 100% |

The data reveals that 86% (69 students) have not participated in any mentorship programs in STEM, while 14% (11 students) have. This suggests that a vast majority of female students have not had access to or participated in mentorship programs, pointing to a potential gap in supportive structures for women pursuing STEM education.

Table 5

| How accessible is career guidance for STEM field at your institution | Frequency | Percentage |
|---|---|---|
| Very accessible | 10 | 12% |
| Accessible | 15 | 19% |
| Neutral | 34 | 43% |
| Inaccessible | 21 | 26% |
| Very inaccessible | 0 | 0 |
| Total | 80 | 100% |

The data shows that 43% (34 students) feel that career guidance for STEM fields at their institution is neutral, meaning it is neither strongly accessible nor inaccessible. A smaller portion, 19% (15 students), find career guidance accessible**,** while 12% (10 students) consider it very accessible**.** On the other hand, 26% (21 students) feel that career guidance is inaccessible**.** Notably, no students reported that career guidance is **very inaccessible**, but the relatively high percentage of students who feel it is inaccessible or neutral indicates room for improvement in providing effective career guidance in STEM fields.

Table 6

| Is career guidance available for women pursing STEM in your institution? | Frequency | Percentage |
|---|---|---|
| Yes | 18 | 23% |
| No | 12 | 15% |
| Not sure | 50 | 62% |
| Total | 80 | 100% |

The data shows that 62% (50 students) are unsure whether career guidance is available for women pursuing STEM at their institution. Meanwhile, 15% (12 students) report that career guidance is not available, and 23% (18 students) confirm that it is available. This suggests a lack of clarity or awareness among the majority of students regarding the availability of career guidance for women in STEM, highlighting a potential gap in communication or resources at the institution.

**Findings**

1. Reasons for Choosing STEM: A significant majority (69%) chose STEM due to personal interest, while 14% were influenced by parental pressure, and only a small fraction cited career motives (2%) or avoidance of other subjects (1%) (Table 1).
2. Future Plans in STEM: Most respondents (68%) plan to pursue a master's degree in STEM, with 29% either unsure or lacking plans for further studies (Table 2).
3. Support and Challenges: Fathers were identified as the primary supporters and inspiration (34%), with 78% feeling supported by teachers and 78.75% by families; however, cultural expectations limited encouragement for some (21%). Challenges faced by women include lack of family support and gender bias (both 21%), with many families still encouraging traditional fields for girls due to marriage expectations (34%). (Tables 3, 4, 5).
4. A significant lack of awareness and accessibility of mentorship programs and career guidance exists for Pakistani women in STEM. Many students are unsure if career guidance tailored for women in STEM is even available. Institutions must enhance the visibility, accessibility, and

relevance of these support systems to foster a more inclusive STEM environment.( table :6, 7 and 8).

**Testing Hypotheses**

Hypotheses 1: Family attitudes and societal perceptions play a crucial role in shaping Pakistani women's interest and participation in STEM education.

Q . How do societal norms and Expectations influence women's decision to purse STEM education?

**$H_0$** = Family attitudes and societal perceptions significantly influence Pakistani women's interest and participation in STEM education.

**$H_1$**= Family attitudes and societal perceptions significantly have no influence Pakistani women's interest and participation in STEM education.

$\alpha = 0.05$

Test statistics:

a. $X^2 = \sum \frac{(o-e)2}{e}$ with difference = r = 1 < -1

1. $\frac{(o-e)2}{e}$

Decision rule = if $X^{2\,tab} > X^2$ call reject $H_o$.

d.f = r-1 = 3 – 1 = 2

Critical value $X^2$ tab = 5.991

Computation

Table 7

| X | Prob. | O | e=80xprob | $(o-e)^2/e$ |
|---|---|---|---|---|
| **1** | 1/3 | 49 | 80 x1/3= 26.66 | $\frac{(49-26.66)^2}{26.66}$= 18.72 |
| **2** | 1/3 | 24 | 80 x 1/3=26.66 | $\frac{(24-26.66)^2}{26.66}$=0.26 |
| **3** | 1/3 | 7 | 80 x 1/3=26.66 | $\frac{(7-26.66)^2}{26.66}$=14.49 |
| | | 80 | total | 33.47 |

Decision:

5.991 < 33.47

Accepted $H_o$ Family attitudes and societal perceptions significantly influence Pakistani women's interest and participation in STEM education.

**Hypothesis 2:** Female students who participate in a mentors a program with female stem professional will show a significant increase in their self-sufficiency and interest in pursuing a stem career compared to the female who does not participate in Mentos program.

Q . Is career guidance available for women pursing STEM in your institution**?**

**$H_0$** = Access to career guidance significantly improves the confidence and clarity of career paths for women pursuing STEM in the institution.
**$H_1$** = Access to career guidance does not significantly impact the confidence and clarity of career paths for women pursuing STEM in the institution.
$\alpha = 0.05$
Test statistics:

$X^2 = \sum \frac{(o-e)2}{e}$ with difference = r = 1 < -1

$$\frac{(o-e)2}{e}$$

Decision rule = if $X^{2\,tab} > X^2$ call reject $H_o$.
d.f = r-1 = 3 – 1 = 2
Critical value $X^2$ tab = 5.991
Computation
Table 8

| X | Prob. | O | e=80xprob | $(o-e)^2/e$ |
|---|---|---|---|---|
| **1** | 1/3 | 18 | 80 x1/3= 26.66 | $\frac{(18-26.66)^2}{26.66}$= 2.81 |
| **2** | 1/3 | 12 | 80 x 1/3=26.66 | $\frac{(12-26.66)^2}{26.66}$=8.06 |
| **3** | 1/3 | 50 | 80 x 1/3=26.66 | $\frac{(50-26.66)^2}{26.66}$=20.43 |
| | | 80 | total | 31.29 |

Decision: 5.991 < 31.29

Accepted $H_o$ Access to career guidance significantly improves the confidence and clarity of career paths for women pursuing STEM in the institution

**Hypothesis 3**: Pathways to career progression for women graduates in STEM fields in Pakistan are influenced by barriers.

Q . What are the most significant barrier to employment for women in STEM field?

**$H_0$** = Pathways to career progression for women graduates in STEM fields in Pakistan are significantly influenced by barriers.

**$H_1$** = Pathways to career progression for women graduates in STEM fields in Pakistan are not significantly influenced by barriers.

$\alpha = 0.05$

Test statistics:

$X^2 = \sum \frac{(o-e)2}{e}$ with difference = r = 1 < -1

$$\frac{(o-e)2}{e}$$

Decision rule = if $X^{2\,tab} > X^2$ call reject $H_o$.

d.f = r-1 = 4 – 1 = 3

Critical value $X^2$ tab = 7.815

Computation

Table 9

| X | Prob. | O | e=80xprob | $(o-e)^2/e$ |
|---|---|---|---|---|
| 1 | ¼ | 31 | 80 x ¼= 200 | $\frac{(31-200)^2}{200}$=142.805 |
| 2 | ¼ | 14 | 80 x ¼=200 | $\frac{(14-200)^2}{200}$=172.98 |
| 3 | ¼ | 19 | 80 x ¼=200 | $\frac{(19-200)^2}{200}$=163.805 |
| 4 | ¼ | 16 | 80 x ¼=200 | $\frac{(16-200)^2}{200}$=169.28 |
| | | 80 | total | 648.87 |

Decision:

7.815 < 648.87

Therefore, $H_o$ is accepted Pathways to career progression for women graduates in STEM fields in Pakistan are significantly influenced by barriers.

Women play multifaceted roles in society, from caregivers to professionals, yet their potential remains underutilized in many fields due to systemic barriers. Education, a fundamental human right and a cornerstone for achieving Sustainable Development Goals (SDGs), is crucial for empowering women and fostering societal progress. However, in Pakistan, the literacy rate for women lags behind men (59% vs. 71%), with cultural norms, poverty, and inadequate educational infrastructure being major contributing factors. This disparity is particularly pronounced in Science, Technology, Engineering, and Mathematics (STEM) fields, where women are significantly underrepresented despite the growing importance of STEM for national development and innovation.

This study signifies the importance and decision of women in Pakistan to pursue STEM higher education. Primarily, driven by strong intrinsic motivation, with a significant 69% of respondents citing a genuine interest and passion for their chosen field. This foundational enthusiasm suggests that personal affinity can be a powerful force in overcoming the well-documented societal and cultural barriers. However, this intrinsic drive does not exist in a vacuum and is significantly shaped by external influences, most notably the family unit. Within this dynamic, fathers emerge as particularly influential figures, serving as the biggest supporters for 34% of students and a primary source of inspiration for 17.5%. The combined support of both parents (28%) further underscores that a united family front is a major enabler. Conversely, the finding that 8% of students report having no familial support highlights a critical barrier, isolating potential talent. Despite this strong personal and familial drive, a significant disconnect exists at the institutional level. A vast majority (84%) of students are unaware of mentorship programs for women in STEM, and over a quarter (26%) find general career guidance inaccessible.

This lack of institutional support is compounded by formidable barriers that women face as they attempt to transition into the workforce. Gender discrimination stands as the most significant obstacle, identified by 39% of respondents as the primary barrier to employment. This pervasive bias is exacerbated by other systemic challenges, including a perceived lack of job opportunities, inadequate professional networks, and a continued lack of mentorship. These issues are not isolated; over a third of respondents reported experiencing a combination of lack of family support, limited access to resources, and gender bias simultaneously. This illustrates the deeply intertwined nature of social, cultural, and systemic barriers that create a challenging environment for women to navigate.

The pathway for women in STEM in Pakistan is characterized by a powerful internal drive that is either facilitated or hindered by external forces. While personal passion is the engine, familial support, especially from fathers is a critical facilitator. However, this potential is often stifled by a lack of structured institutional support and is ultimately confronted by pervasive gender discrimination and systemic barriers in the professional sphere. Therefore, fostering greater participation requires a multi-pronged strategy that focuses on nurturing intrinsic interest, actively engaging families as allies, fundamentally strengthening mentorship and guidance within universities, and implementing decisive policies to dismantle gender-based barriers in the workplace.

This research focused on factors shaping women's decisions to pursue STEM education in universities. It examined how family attitudes, societal perceptions, and cultural expectations on women’s educational choices, while also evaluating the availability and accessibility of resources. The study also examined barriers to career progression for women in STEM fields and highlights the role of parental support in fostering their interest and success. By addressing these issues, this research aims to contribute to gender equality in STEM education and careers, aligning with SDG goals 4 (quality education), 5 (gender equality), and 8 (decent work and economic growth). The findings will provide actionable insights for policymakers, educators, and stakeholders to develop

strategies that empower women in STEM and enhance their representation in these transformative fields.

**Conclusion and recommendations**

This study underscores the multifaceted challenges and opportunities for women in STEM education in Karachi, Pakistan. Despite significant personal interest among female students in STEM fields, systemic barriers such as cultural norms, gender bias, and lack of family support continue to hinder their full participation and progression. Findings reveal that while many women aspire to pursue advanced STEM education, societal expectations and inadequate mentorship often limit their potential. In the last fifteen years in Pakistan, women's access to STEM education has improved (HEC,2024). Additionally, the supportive environments both familial and institutional would help encouraging women to pursue and excel in STEM fields.

To address the policy issues, integrated gender-sensitive STEM curricula and pedagogies at school and university level, teacher training to reduce gender stereotypes and biases in classrooms and scholarship offers to increase women's enrollment are some practical recommendations to increase female participation and enrollment in STEM. Additionally, research and evaluation of programs providing targeted career guidance and supportive ecosystems for women is also necessary. Initiatives must focus on reducing cultural and gender barriers, enhancing mentorship opportunities, and advocating for inclusive policies that enable women to thrive in STEM careers. By empowering women in STEM, Pakistan can harness the potential of this underrepresented group to drive innovation, economic growth, and sustainable development. Implementing the recommendations derived from this research will not only contribute to gender equity in education but also align with global Sustainable Development Goals, paving the way for a more inclusive and progressive society.

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