

# Nurturing Women in STEM: A Multifaceted Approach for India

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## ABSTRACT

Despite advancements in education, women remain underrepresented in India's Science, Technology, Engineering, and Mathematics (STEM) workforce, impacting diversity and innovation. The author examined 74 articles published between 2004 and 2024 by reviewing the existing literature. The multifaceted challenges hindering women's participation and growth in STEM fields within India are explored. While acknowledging global barriers, it emphasizes India's unique socio-cultural context, including patriarchal norms, early marriage pressures, the rise of nuclear families with diminished extended family support, and inadequate institutional support. During the investigation, it is observed that the majority of research is concentrated on the difficulties women experience in academia. The research advocates for a holistic approach, fostering an environment where women's STEM aspirations can flourish. Key recommendations include early STEM exposure, addressing biases, cultivating inclusive environments, promoting flexible work arrangements, and challenging stereotypes. Additionally, it is crucial to address the challenges of modern times faced by women in nuclear families, such as childcare concerns and lack of family support, to create a truly equitable STEM landscape. Through concerted efforts at all levels, India can nurture a supportive ecosystem for women in STEM, unlocking the full potential of its female talent pool and fostering a more innovative and prosperous future.

**Keywords:** Women in STEM, Underrepresentation, Indian STEM workforce, multifaceted approach, Comprehensive intervention, Supportive ecosystem

## INTRODUCTION

Science Technology and Innovation (STI) are the fundamental building blocks of sustainable development for a nation. These disciplines cultivate individuals who contribute to the advancement of various sectors including health, education, food security, nutrition, transportation, infrastructure, energy, communications, and more. STEM advancements are pivotal in addressing worldwide issues such as disease prevention, environmental conservation, improved energy utilization, and enhanced educational practices [1].

Despite significant advancements, women remain underrepresented in STEM fields globally [2]. This disparity is attributed to various factors, including societal stereotypes, lack of role models, and institutional biases [3]. This article proposes a comprehensive approach to nurturing women in STEM, drawing on existing research and successful case studies.

While India produces the highest percentage of women STEM graduates in the world (about 40%), their share in STEM jobs in the country is very low at 14% and needs to be improved [4]. This significant drop

from the proportion of female STEM graduates indicates a "leaky pipeline" phenomenon, where women are disproportionately lost from STEM fields.

The underrepresentation of women in STEM workforce highlights the need to address systemic barriers and create a more supportive environment for women in these fields.

## LITERATURE REVIEW

Existing literature on women in STEM globally has highlighted a range of barriers, including gender stereotypes, implicit bias, lack of role models, and work-life balance challenges [4-7]. In a study [6] a multi-faceted understanding of why women are underrepresented in STEM fields and why women leave STEM careers.

The study carried out in [8] revealed a significant underrepresentation of women in STEM fields across Indian universities and institutes. The study estimated the proportion of women faculty across various STEM disciplines in India, revealing a median base rate of 16.7% across all fields surveyed. This means that, on average, only about 17 out of every 100 faculty members in these fields are women. They found Biology had the highest representation of women at 22.5%, while Engineering had the lowest at 8.3%. This indicates a significant variation in gender representation across different STEM fields. The research also highlighted the underrepresentation of women speakers at STEM conferences in India and lower proportions of women faculty at Higher-ranked institutions.

Research has pointed to the lack of supportive work environments and mentorship opportunities as contributing factors to the attrition of women from STEM fields [9].

A comprehensive analysis of the representation and experiences of women in STEM fields within the Council of Scientific and Industrial Research (CSIR) in India was presented in [4]. Based on information on CSIR women's career, their STEM journey, challenges, hurdles, and paradigms some of the major findings include: Underrepresentation in Leadership, Funding Disparities in research projects, Gender Bias and Discrimination, Work-Life Challenges, Sexual Harassment. The report emphasized the need for systemic changes and targeted interventions to achieve gender parity in STEM within CSIR and create a more inclusive and supportive environment for women scientists and researchers.

Gender differences in STEM education participation at the expense of girls are already visible in early childhood care and education (ECCE) and become more visible at higher levels of education. Girls appear to lose interest in STEM subjects with age, and lower levels of participation are already seen in advanced studies at secondary level. By higher education, women represent only 35% of all students enrolled in STEM-related fields of study. Gender differences also exist in STEM disciplines, with the lowest female enrolment observed in information, communication and technology (ICT); engineering, manufacturing and construction; and natural science, mathematics and statistics. Women leave STEM disciplines in disproportionate numbers during their higher education studies, in their transition to the world of work and even during their career cycle [2].

Indian Institute of Technologies (IITs), India's top elite institutions which are open window of opportunities to students across the world are also found with the underrepresentation of women in STEM [10].

The findings indicated a significant gap between males and females in faculty positions at IITs. The combination of individual (interest and self-efficacy) and contextual factors (parental support and role models) had impacted the female researchers' decision to select and pursue higher studies in STEM in India [11].

Following the completion of academic programs, the professional environment emerges as a pivotal determinant influencing the retention rates of women within STEM disciplines. Many women experience a multitude of obstacles during their mid-career stages that serve as contributing factors to their departure from careers in STEM sectors. An unsupportive workplace atmosphere, excessive work demands, ambiguous criteria regarding career advancement, and the definition of success rank among the predominant influences on women's choices to exit the field. STEM domains are frequently characterized by rigid, exclusionary, and predominantly male-centric cultures that lack support or appeal for women and underrepresented minorities. The underrepresentation of women within STEM occupations also translates into a dearth of role models for younger generations of girls and women, thereby diminishing their motivation to pursue careers in these fields [7].

In families, it is often observed that women assume the role of the principal caregiver, and they exhibit a greater propensity to withdraw from their professional engagements or completely disengage from the workforce when confronted with the dilemma of balancing occupational responsibilities and familial obligations [12].

The challenges faced by women engineers in India were highlighted in [5]. The study reveals that despite an increase in the number of women graduating with engineering degrees, they encounter significant hurdles in securing employment and advancing in their careers. The authors attribute this to factors such as societal biases, limited job opportunities, and a lack of supportive policies for working mothers. The research underscores the need for comprehensive measures to address these challenges and create a more inclusive environment for women in the engineering profession in India.

An Inter-Academy Panel report from 2016, [13] highlights the persistent underrepresentation of women in Science and Technology (S&T) in India. The report underscores that despite policy interventions and increased educational attainment, women continue to face significant challenges in securing employment, attaining leadership roles, and receiving recognition in the form of fellowships and awards. The data presented reveals a stark gender disparity in key areas such as academia and research institutions, where women are disproportionately less likely to hold positions as principal investigators or team leaders. This underrepresentation not only limits individual opportunities for women but also hampers the overall progress and diversity of the S&T landscape in India. The report serves as a call to action, emphasizing the need for further initiatives and systemic changes to address these disparities and create a more inclusive environment for women in S&T [13].

The study [14] highlighted that despite an increasing number of women graduating with STEM degrees in Australia, they encounter significant barriers to retention and advancement in their careers. The authors identified several key challenges, including the persistence of a gendered workplace culture, societal biases and stereotypes about women's abilities in STEM, and the difficulties in balancing work and family responsibilities, particularly motherhood. The research emphasized the need for comprehensive measures to tackle these deep-rooted issues and create a more inclusive and supportive environment for women in STEM.

Research on STEM employment has predominantly concentrated on the academic careers of undergraduate students pursuing STEM majors and has tracked gender gaps in the faculty hiring process, tenure, research collaboration, and research publishing. Nevertheless, there exists a notable paucity of investigation into STEM career trajectories beyond the confines of academia, with the majority of existing research being primarily focused on the STEM labor market within the Indian context.

## METHODOLOGY

### Research Design

This research adopts a descriptive research design. This approach aims to systematically gather, analyze, and interpret existing data from a heterogeneous array of sources such as Indian governmental websites, peer-reviewed journals, academic periodicals, and an assortment of published literature on the underrepresentation of women in STEM in India. By examining secondary sources, the study provides a comprehensive overview of the current state of affairs, identifying key trends, challenges, and potential solutions.

### Data Collection

**Source Identification:** Relevant documents were identified through a systematic search using platforms like Google Scholar and academic databases such as IEEE, Science Direct, Wiley Online Library, SSRN, JSTOR, etc.

**Search Terms:** The search terms used included "Women in STEM," "Underrepresentation," "Indian STEM workforce," "multifaceted approach," "Nurturing women in STEM," and "Supportive ecosystem."

**Timeframe:** The primary focus was on publications from 2019 to 2024; however, certain earlier publications have also been scrutinized.

**Document Selection and Classification:** The identified documents were evaluated for their relevance to the Indian context and their association with STEM careers. They were then categorized accordingly.

### Data Analysis

**Literature Review:** The collected literature was analyzed to address the research questions and explore related domains.

**Synthesis:** Key findings, trends, and patterns were identified and synthesized to form a coherent narrative. By following this methodology, the research provides a comprehensive and systematic analysis of the underrepresentation of women in STEM in India, contributing to a better understanding of the issue and informing potential interventions.

The objective of this study is to examine a multifaceted approach for fostering the involvement of women in STEM fields within India.

The research inquiries being addressed are as follows:

RQ1: What are the specific barriers faced by women in India that hinder their entry and progression within the STEM workforce, despite achieving higher levels of education?

RQ2: How can a multifaceted approach, encompassing education, policy, mentorship, and advocacy, effectively increase the representation of women in the Indian STEM workforce?

## BARRIERS THAT IMPEDE WOMEN'S PARTICIPATION AND PROGRESS IN STEM FIELDS

The challenges faced by women in Science, Technology, Engineering, and Mathematics (STEM) fields are multifaceted and persistent, transcending geographical boundaries. However, the specific manifestations and intensity of these challenges can vary significantly depending on the socio-cultural context. This section provides a comprehensive analysis of the global challenges faced by women in STEM, with a particular focus on the unique issues encountered in India. By examining both the global and Indian contexts, this section highlights the necessity of tailored interventions to promote gender equality in STEM fields.

Globally, women in STEM face several well-documented challenges viz., Work-life balance, Gender bias and discrimination, Lack of representation and role models, Stereotypes and societal expectations etc.,

which hinder their full participation and advancement in these fields [15-21].

In the Indian context apart from all those challenges, the Indian socio-cultural landscape presents additional, unique challenges as discussed below:

**Patriarchal social structures:** In India, patriarchal norms significantly hinder women's access to education and career opportunities, particularly in STEM fields. Despite increasing enrollment in higher education, societal expectations and gender stereotypes continue to restrict women's professional aspirations and participation in the workforce. Addressing these issues requires comprehensive societal reforms and targeted interventions. Patriarchal ideologies dictate what constitutes "respectable work" for women, often limiting their career choices to socially acceptable roles [22]. Gender bias in educational settings leads to differential treatment, affecting women's confidence and aspirations in pursuing STEM subjects [23]. Women in STEM face societal stereotypes that suggest they are less suited for these fields, resulting in underrepresentation in both academic and professional environments [24, 25]. The societal expectation that women will prioritize family responsibilities over their careers creates significant barriers to their participation and advancement in STEM [26].

**Lack of institutional support:** Many Indian institutions struggle with the implementation of gender-sensitive policies and infrastructure, which is crucial for fostering a safe and equitable environment for women. Despite legislative frameworks, significant gaps remain in addressing issues such as childcare facilities, flexible work arrangements, and mechanisms to combat sexual harassment. The absence of such support structures creates a challenging and often hostile environment for women in STEM.

The workplace environment in India can often be antagonistic towards women, with harassment and discrimination being prevalent issues. This creates a hostile atmosphere that discourages women's engagement and career progression. Various forms of harassment, including sexual, physical, psychological, and cyberbullying, are common, impacting women's well-being and professional stability. The Sexual Harassment of Women at Workplace Act (2013) [27] mandates the establishment of Internal Complaints Committees (ICCs) in educational institutions, yet many institutions fail to implement these effectively due to bureaucratic inefficiencies and lack of training for committee members [28, 29]. In another research it is evidenced that Women in India face multiple forms of harassment at work, including sexual harassment, discriminatory harassment, and power harassment. These not only affect their mental and physical health but also their professional and financial stability [30].

Despite legal frameworks aimed at protecting women, challenges persist in ensuring a safe and equitable work environment. The UGC Regulations (2015) [31] aimed to enhance gender sensitivity, but the actual practices in classrooms and curricula often overlook these guidelines, leading to a disconnect between policy and practice [32].

**Gender-Sensitive Infrastructure:** Childcare facilities and flexible work arrangements are often absent, limiting women's participation in academia and contributing to a hostile work environment [33]. The absence of thorough gender sensitivity training programs worsens the problem, as many institutions neglect to prioritize education or awareness campaigns.

While there are frameworks in place to address these issues, the effectiveness of policies is undermined by inadequate implementation and a lack of commitment to creating a genuinely supportive environment for women in Indian higher education.

**Early marriage and family pressures:** Early marriage and societal pressure to start families at a young age disrupt women's education and career trajectories in STEM [34].

The challenge of re-entering the workforce after a career break is significantly compounded by a lack of

support for women, as highlighted in various studies. Women face numerous barriers, including identity struggles, organizational culture, and societal attitudes, which hinder their reintegration into professional environments. The role of organizational policies is crucial. Supportive measures such as flexible work arrangements and targeted reskilling programs significantly enhance women's reintegration into the workforce [35].

Organizational cultures often favor younger employees, creating age-related biases that returning women must overcome. This is compounded by gender inequity and the need to prove that skills have not diminished during the break [36].

In fields like computing and technology, women returning to work face specific challenges, such as keeping up with rapid technological advancements [37].

Limited awareness and access to opportunities: In India, the limited awareness of STEM careers among girls and young women is a multifaceted issue influenced by societal norms, educational environments, and the lack of role models. Addressing these challenges is crucial for fostering greater participation in STEM fields. Societal expectations often discourage girls from pursuing STEM, reinforcing the notion that these fields are male-dominated [38, 39]. Many families prioritize traditional roles for women, which can limit their educational and career aspirations [24, 39].

Schools often lack inclusive environments that encourage girls to explore STEM subjects, leading to decreased confidence and interest [38, 40]. The absence of female role models in STEM fields contributes to a lack of aspiration among young women [38, 41].

Shortage of Science and Maths Teachers Hinders Quality Education: The scarcity of qualified science and mathematics teachers is a significant issue with far-reaching consequences for students. This shortage affects student performance, educational quality, and even national competitiveness. The problem is complex, involving various factors such as teacher preparation, motivation, and systemic educational policies.

India faces a staggering 8.4 lakh teaching vacancies in government schools across India in the primary as well as in secondary schools, primarily due to rapid population growth and inadequate public funding for education [42]. This alarming shortage of teachers in India, poses a significant threat to the education system. Widespread issues in teacher education and recruitment are making this crisis worse, limiting the quality and accessibility of education.

The Centre of Excellence in Teacher Education (CETE) at Tata Institute of Social Sciences (TISS) [43] reported about the teacher requirements. Across all schools, the highest requirement reported in was for Mathematics and Science. Another serious issue reported was that for teachers teaching in middle and secondary schools, their under graduate subject specialisation and the subjects they were teaching have no match. It was also found that in 55% of cases in government schools and 50% cases in private schools, mathematics like subject was being taught by a teacher who had not studied mathematics in their under graduation.

In Tanzania, the shortage of science and mathematics teachers has led to poor student performance in these subjects. This creates a cycle where fewer students graduate with the necessary skills to become teachers, exacerbating the shortage [44].

A study in Nigeria found that students taught by qualified teachers performed significantly better in mathematics than those taught by less qualified teachers. This highlights the importance of teacher qualifications in student success [45].

The lack of quality education in science and maths creates a knowledge gap for students. They enter higher

education or the workforce with a weak background in these fundamental subjects, limiting their opportunities and potential.

While the government is aware of these challenges and has proposed reforms through the New Education Policy (NEP) 2020 [46], the implementation of this policy remains inconsistent, leaving the education system vulnerable to ongoing crises.

**Modern family structures:** In today's world, working women face particular challenges due to the rise of nuclear families. With parents and children living on their own, women often find it difficult to balance the demands of their careers with household duties and childcare, creating a unique set of obstacles.

In the absence of extended family members or elders living nearby, working mothers often lack the built-in support system that was more common in previous generations. This means that they have to find alternative solutions for childcare, which can be both expensive and stressful.

The traditional role of extended family in providing childcare support has diminished, leading to increased reliance on formal childcare services. This shift can be financially burdensome for working mothers, who must balance work commitments with childcare responsibilities [47]. Even when childcare arrangements are in place, such as daycare or nannies, the emotional burden on working mothers remains. The constant worry about their child's well-being can make it challenging for them to focus fully on their work and can lead to feelings of guilt and anxiety and hence affecting in their career growth.

**Inadequate Facilities in Schools and Colleges:** The lack of essential laboratory facilities in educational institutions significantly impacts the quality of education and the preparedness of students for industry-specific challenges.

The absence of necessary tools limits practical learning experiences, which are crucial for understanding complex concepts, especially in fields like science and technology [48].

A study on maritime students highlighted that while facilities like seamanship labs and bridge simulators are crucial, the expertise of instructors also plays a significant role in student learning. This suggests that both infrastructure and teaching quality need to be addressed to improve educational outcomes [49].

**STEM Graduates Opting for Non-STEM Careers:** While not strongly supported by research, anecdotal evidence from news, social media, and other sources suggests that STEM graduates in India are increasingly opting for non-STEM careers. This shift can be attributed to several factors, including job scarcity in STEM fields and lucrative opportunities in non-STEM sectors. These factors may be influenced by socio-economic, cultural, and educational dynamics.

A significant number of individuals with backgrounds in Science, Technology, Engineering, and Mathematics (STEM) fields are pursuing careers outside of their core domain. This trend is particularly evident among successful candidates in the UPSC civil services examination, bank employees, and other civil servants who often have engineering or medical degrees.

The maximum number of officers recruited are from the technical and medical background. Over 70% of the recruits in the civil services by UPSC nowadays are from technical streams [50].

The trend of STEM graduates pursuing non-STEM careers raises important questions about the alignment of India's education system with its evolving job market. The precise reasons behind this career shift remain undocumented. Further research is needed to understand the underlying causes and implications of this phenomenon.

## **A MULTIFACETED APPROACH**

To enhance the retention of women in STEM careers, comprehensive policy interventions are essential

across educational, workplace, and societal levels. These interventions can address widespread barriers and promote a more inclusive environment for women.

The interplay between policy, education, and industry in addressing the above-mentioned challenges are examined in this section and strategies are proposed to enhance women's participation in STEM.

### **Educational Level Interventions**

**Early exposure to STEM:** Encouraging girls' interest in STEM from a young age through interactive programs, workshops, and mentorship opportunities can lay the groundwork for future careers. Such initiatives not only challenge gender stereotypes but also provide hands-on experiences that make STEM subjects more appealing. A systematic review highlights the need for early-stage interventions in primary and secondary education to address gender disparities and promote STEM disciplines as viable career paths for girls [51].

**Ensuring Subject-Matter Expertise:** When teachers are teaching within their area of expertise, they are more likely to provide high-quality instruction that fosters deep understanding and critical thinking skills. Ensuring alignment between a teacher's undergraduate subject specialization and the subjects they teach, regardless of whether they are in a private or government school, is crucial for effective education in middle and secondary schools.

Schools should prioritize hiring teachers whose undergraduate degrees align with the subjects they will be teaching.

In cases where perfect alignment is not possible, schools should explore creative solutions, such as collaborating with nearby schools, use of ICT etc.

**Hands-On Learning and Creativity:** Early exposure to modern STEM technologies can transform education by fostering creativity and innovation. A study in Bhutan demonstrated that hands-on experimental learning with technologies like automation and AI significantly increased students' understanding and interest in STEM [52]. Programs like the KIBO robotics initiative for young children have shown that engaging girls in engineering activities at an early age can effectively boost their interest in STEM fields [52].

### **Addressing Biases**

Progressive teaching strategies that challenge stereotypes and promote inclusivity are crucial, as noted by [53]. Interventions that educate students about the impact of gender stereotypes can improve academic outcomes for underrepresented minority women in STEM, suggesting that awareness can mitigate bias [54].

**Inclusive STEM Outreach:** Outreach programs targeting underrepresented groups are crucial for inclusive STEM engagement. A model implemented in Missouri provided STEM activities to students from low-income, racially minoritized schools, resulting in increased interest and knowledge in STEM among participants [55].

The "Code Explorers" summer camp in Mexico, designed exclusively for girls, successfully increased participants' interest in technology and engineering careers by offering coding sessions and inspirational talks from female tech leaders [56].

**Impact of Informal STEM Learning Experiences:** Informal STEM learning experiences (ISLEs) play a significant role in shaping students' interests in STEM disciplines. Participation in diverse ISLEs is positively associated with increased interest in science, although stereotypical discourses can still influence gender-specific interests [57].

**Fostering Inclusivity and Gender Equity:** Initiatives like the NASA Human Exploration Rover Challenge



have emphasized inclusivity and female participation in STEM. By designing innovative workshops, these programs have successfully engaged a significant number of female participants, fostering essential skills such as problem-solving and critical thinking [58].

While these initiatives highlight the positive impact of early STEM exposure, it is important to address the barriers that still exist, such as accessibility and cultural stereotypes, which can hinder the participation of girls and underrepresented groups in STEM. Continued efforts to create inclusive and supportive environments are essential for sustaining interest and engagement in STEM fields.

### **Workplace Level Interventions**

Flexible work arrangements, mentorship programs, pay equity, and addressing bias are crucial strategies to enhance women's retention in STEM fields. These initiatives collectively support women in balancing professional and personal commitments, advancing their careers, and ensuring a fair and inclusive workplace.

**Flexible Work Arrangements:** Flexible work policies, such as remote work and flexible hours, are essential for women to manage work-life balance effectively. Research highlights that while flexible working arrangements are beneficial, they are still underdeveloped, and their impact on gender and social inequalities needs further exploration [59].

Organizations that have implemented flexible work options, such as the Bank's initiatives, have seen positive outcomes in supporting employees returning from parental leave and promoting work-life balance [60].

**Mentorship and Sponsorship Programs:** Mentorship programs play a vital role in empowering women in STEM by providing guidance and support. These programs help women develop leadership skills and navigate their professional journeys, as evidenced by the Mentoring in Science [61].

The importance of mentorship is further emphasized in tech fields, where strategic policy-making and organizational change can foster an inclusive environment, enhancing women's participation and innovation [62].

**Pay Equity and Transparency:** Ensuring pay equity and transparent compensation structures is crucial in addressing the gender pay gap. While the provided papers do not directly address pay equity, the emphasis on inclusive policies and diversity initiatives suggests that fair compensation is a component of broader gender-inclusive strategies [62].

**Addressing Bias and Discrimination:** Implementing strict policies against workplace harassment and discrimination is essential for creating a safe and inclusive environment. The study on women's participation in tech highlights the need for long-term commitment to gender-inclusive policies to reduce disparities and foster a supportive workplace [62].

While these strategies are pivotal, it is important to recognize that achieving work-life balance and gender equity requires a collective effort from organizations, policymakers, and communities. Educating family members and fostering a supportive culture at home and work can further enhance women's work-life balance and career satisfaction [63].

There ought to be the establishment of on-site childcare facilities and lactation rooms within professional environments. The availability of such amenities can profoundly influence women's work-life equilibrium, overall job fulfilment, and opportunities for career progression.

The government must ensure the equitable distribution and monitoring of educational resources of every educational institution on a yearly basis. This includes providing necessary facilities and infrastructure to support high-quality education, particularly in rural areas. The lack of adequate facilities, especially

laboratory equipment, teachers in rural schools and colleges presents a significant barrier to quality education.

Government has to take proactive steps to fulfil vacant posts of Teachers in subjects of the STEM field in schools, colleges to ensure that students have access to high-quality STEM education.

### **Societal Level Interventions**

**Challenging Stereotypes through Social Media influence:** Promoting positive media representations of women in STEM and challenging traditional gender roles can encourage girls to pursue STEM careers. Social media platforms like Instagram and Twitter have become powerful tools for promoting positive portrayals of women in STEM. A study analyzing Instagram posts with the hashtag #WomenInSTEM found that users often present counter-gender-stereotyped portrayals, highlighting their STEM identities and achievements. This self-presentation helps in negotiating identity and promoting equity in STEM through outreach programs featuring women role models [64]. Sentiment analysis of over 250,000 tweets related to women in STEM revealed a generally positive public attitude. Notably, positive sentiments were significantly correlated with dates celebrating women's achievements, such as International Women's Day. This indicates that media campaigns tied to these events can effectively enhance public perception and encourage more women to enter STEM fields [65]. Traditional media, such as newspapers, have historically emphasized gender in ways that may reinforce stereotypes. However, recent trends show a shift towards focusing more on women's scientific accomplishments rather than their gender roles. Despite this progress, an experiment found no significant effect of gender-emphasizing articles on readers' gender biases, suggesting that while portrayals are changing, their impact on bias may be limited [66].

**Community Outreach:** Engaging communities through STEM awareness programs and events can inspire young girls and expose them to diverse career paths. Service-learning, science exhibition, storytelling activities have been shown to empower women in rural communities by challenging traditional roles and advocating for equal opportunities in STEM [67]. Community programs that expose girls to STEM professionals and documentaries can foster interest and motivation in STEM careers, as evidenced by studies in African countries [68]. Community science fairs offer alternative ways to engage students, particularly those from historically marginalized communities, by moving beyond traditional classroom settings. These fairs can increase representation in STEM by providing hands-on experiences and exposure to diverse role models [69].

**Career awareness programs** are particularly impactful in rural areas, where cultural stereotypes often discourage girls from pursuing STEM. By exposing girls to STEM careers and role models, these programs can change perceptions and increase the number of girls interested in STEM fields [70].

**Family Support:** Educating families about the importance of supporting girls' interest in STEM is crucial for creating a nurturing environment that encourages aspiring female scientists and engineers. Family support plays a significant role in shaping educational and career paths, as it provides the instrumental backing that young individuals need to pursue their interests and overcome challenges. Parents often take proactive measures to help their children realize their passions and interests, which is essential for fostering a supportive environment for girls interested in STEM fields [71].

This support is particularly vital in the context of STEM education, where gender disparities still exist.

### **Government Intervention**

The Indian government has implemented several initiatives to enhance women's participation in STEM fields, addressing barriers from education to career advancement. These initiatives, such as the Vigyan Jyoti Scheme, scholarships, and policies like Gender Advancement for Transforming Institutions (GATI)

and Knowledge Involvement in Research Advancement through Nurturing (KIRAN), Science, Technology, and Innovation Policy (STIP) 2020 [72], Pragati Scholarship for technical education and the Indo-U.S. Fellowship for Women in STEM aim to create a supportive environment for women in STEM. However, challenges remain, and further efforts are needed to fully bridge the gender gap.

Regular assessment of government interventions is essential to measure impact and identify areas for improvement, ensuring effective implementation of programs.

Mandating policies for flexible work arrangements (FWAs) such as remote work options, flexible hours, and extended maternity leave can significantly aid women in balancing career and family responsibilities. These policies not only enhance work-life balance but also contribute to employee satisfaction and retention. Organizations that implement FWAs can experience higher levels of employee satisfaction and retention. This is because FWAs allow employees to tailor their work schedules to better fit their personal lives, which is crucial for women balancing family responsibilities [73, 74].

The government must implement proactive policies and facilitate streamlined processes to fill vacant academic positions in a timely manner. Government has to work on developing a centralized platform to track academic vacancies across all institutions. This will provide real-time data on the number and types of vacancies, enabling faster responses.

## DISCUSSION AND CONCLUSION

Addressing the gender gap in STEM for Indian women requires a holistic approach that tackles societal, institutional, and individual barriers. The research highlights the importance of early STEM exposure, addressing biases, and fostering inclusive environments from childhood. It also emphasizes the need for workplace interventions and societal initiatives to challenge stereotypes. A concerted effort across all levels is essential to create a truly equitable STEM landscape for women in India. The present study unveils the complex interplay of factors that hinder women's participation and progress in STEM fields within the Indian context. While global challenges like work-life balance, gender bias, and limited role models persist, deeply ingrained patriarchal norms, early marriage pressures, and inadequate institutional support create a unique and formidable barrier for Indian women.

The research underscores the urgency of addressing these challenges at multiple levels. Early STEM exposure and a supportive educational environment are critical for sparking girls' interest and building their confidence. However, the scarcity of qualified science and math teachers in India poses a significant hurdle, highlighting the need for investment in teacher training and recruitment. Moreover, ensuring subject-matter expertise by aligning teacher specialization with their teaching assignments is crucial for fostering a high-quality learning experience.

The study also emphasizes the importance of workplace interventions to retain women in STEM careers. Flexible work arrangements, mentorship programs, and addressing bias and discrimination are essential for creating an inclusive and supportive work environment. Policies that enable women to balance work and family responsibilities, such as on-site childcare facilities and extended maternity leave, are critical for ensuring their continued participation in the workforce.

Societal interventions play a crucial role in challenging stereotypes and fostering a supportive environment for women in STEM. Leveraging social media to promote positive role models, engaging communities through STEM awareness programs, and educating families about the importance of supporting girls' aspirations can collectively contribute to shifting societal perceptions and creating a more inclusive STEM culture.

While the Indian government has taken significant strides through initiatives like the Vigyan Jyoti Scheme and GATI, challenges remain. Addressing the shortage of STEM teachers, ensuring equitable resource distribution, and promoting flexible work arrangements are crucial next steps. Regular assessment of existing interventions is also essential to identify areas for improvement and ensure their effective implementation.

The study's findings highlight the need for a comprehensive and sustained effort to create a more equitable STEM landscape in India. Addressing the complex interplay of societal, educational, and workplace barriers requires collaboration between policymakers, educational institutions, industries, and communities. By implementing the recommended multi-pronged approach, India can unlock the full potential of its female talent pool and foster a thriving and inclusive STEM ecosystem.

While government initiatives and policies lay the foundation, their effective implementation and continuous assessment are crucial. Merely formulating policies isn't enough; the government must ensure these policies translate into tangible action on the ground. Adequate funding and infrastructure are essential for the success of any policy. The government must ensure equitable distribution of resources to educational institutions, particularly in rural areas, to bridge the gap in access to quality STEM education. Educational institutions serve as the breeding ground for future STEM professionals, and their role in cultivating an inclusive environment is paramount. Educational institutions need to cultivate inclusive environments, provide quality STEM education, and challenge biases. Institutions need to develop curricula and teaching methods that challenge gender stereotypes and promote inclusivity. This includes showcasing the contributions of women in STEM, creating safe spaces for discussion, and addressing unconscious biases.

Creating a supportive and inclusive workplace is key to retaining women in STEM careers.

India urgently needs strict policies against harassment and discrimination to create a safe and welcoming work environment for women. These should be implemented alongside flexible work arrangements such as remote work options, flexible hours, and extended maternity leave.

Societal interventions promoting positive role models and challenging stereotypes are vital.

To create a truly equitable STEM landscape for women in India, a concerted effort across all levels involving all stakeholders is essential.

Government policies, educational institutions, workplaces, and society at large must work together to break down barriers and create a supportive ecosystem where women can thrive in STEM. This requires not only policy changes but also a shift in societal attitudes, a commitment to quality education, and inclusive practices in the workplace. By addressing these challenges head-on, India can unleash the full potential of its female talent pool and build a more innovative and prosperous future.

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