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WOMEN IN STEM IN INDIA: PROBLEMS AND PERSPECTIVES — A SECONDARY ANALYSIS

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RESEARCH ARTICLE

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Abstract

Despite steady improvements in girls' participation in science at school and rising female enrolment in higher education, women remain under-represented in many STEM fields in India's academic and professional sectors. This paper uses secondary data from national surveys, policy reports and peer-reviewed literature to map the current landscape of women in STEM in India, identify structural and sociocultural barriers that cause leakage across the pipeline, and discuss policy and institutional responses. Key findings show relatively high female participation at certain educational stages, but major attrition before and after graduation, low representation in R&D and leadership, and persistent workplace biases and care-burden penalties. Recommendations include targeted pipeline interventions, institution-level gender reforms, labour-market measures (flexible careers, return-ships), and a sustained data-driven approach to monitoring equity.

Keywords: *Women in STEM, Gender gap, Higher education, Labour market, Policy*

Introduction

Science, Technology, Engineering, and Mathematics (STEM) are vital drivers of economic growth, technological advancement, and global competitiveness. Women's equitable participation in these fields is not only a matter of social justice but also a prerequisite for harnessing the full talent pool in knowledge economies. Despite steady progress in women's education, persistent gender disparities continue to shape India's STEM landscape.

India has witnessed significant improvements in girls' educational attainment over the past two decades. The All India Survey on Higher Education (AISHE 2021–22) reports that women account for nearly 49% of total enrolments in higher education, with increasing participation in science-related courses (Ministry of Education, 2023). However, disciplinary differences remain stark. Women are better represented in life sciences and basic sciences, whereas engineering, technology, and computer science still exhibit low female participation (IWWAGE, 2024). UNESCO's global figures reflect similar trends, with women comprising only around one-third of STEM graduates worldwide and about 28% of researchers, a figure that has changed little over the last decade (UNESCO, 2019).

The "leaky pipeline" phenomenon is particularly evident in India, where relatively high female enrolment in STEM education does not translate into equivalent workforce participation. Studies indicate that although women constitute a sizable proportion of STEM graduates, their representation in research, academia, and industry roles declines sharply, with estimates of female STEM workforce participation ranging between 14–30% depending on the sector (CII, 2023; ORF, 2021). Contributing factors include sociocultural expectations, lack of institutional support, workplace biases, and structural barriers that discourage long-term career retention (CSIR-NIScPR, 2022).

Understanding these attrition points is critical for policy formulation. This article undertakes a structured secondary analysis of national statistics, international data, policy reports, and scholarly literature to map problems and perspectives on women in STEM in India. By synthesising quantitative indicators and qualitative insights, the paper highlights key challenges, identifies systemic leakages, and suggests actionable interventions. The goal is to provide a consolidated evidence base for advancing gender equity in STEM, enabling India to strengthen its innovation capacity while promoting inclusive development.

Background and Literature Review

Global evidence consistently highlights the gender imbalance in STEM. According to UNESCO and the UNESCO Institute for Statistics (UIS), women constitute only around one-third of STEM graduates and less than one-third of the world's researchers, a figure that has remained stagnant for over a decade (UNESCO, 2019). Structural inequalities, sociocultural barriers, and limited institutional support continue to prevent women from fully participating in scientific and technological fields.

In India, national surveys show a more complex picture. The *All India Survey on Higher Education* (AISHE 2021–22) indicates that women now account for nearly half of all higher education enrolments, reflecting progress in overall access (Ministry of Education, 2023). However, gender gaps persist across STEM disciplines. Women are relatively better represented in life sciences, medicine, and basic sciences, but significantly underrepresented in engineering, technology, and computer science, where male enrolments remain dominant (IWWAGE, 2024). This uneven distribution suggests that progress in women's education has not translated into proportional participation across all STEM fields.

The disconnect between education and employment has been described as the "leaky pipeline" phenomenon. Although India produces a substantial number of women STEM graduates, their transition into the workforce is limited. A Confederation of Indian Industry (CII, 2023) report notes that female representation in STEM occupations often hovers between 14–30%, far below their educational presence. Similarly, Observer Research Foundation (ORF, 2021) highlights the "inexplicable gap" between women's high levels of participation in education and their low share in research, academia, and industry careers. This attrition reflects systemic constraints rather than individual choice alone.

The literature broadly clusters these constraints into three categories. First, sociocultural norms and gendered expectations restrict women's subject choices and career aspirations. Early socialisation, family pressures, and concerns over safety and mobility discourage girls from pursuing technical fields that require relocation, long hours, or fieldwork (IWWAGE, 2024). Second, institutional factors within universities and research organisations exacerbate inequalities. These include limited mentoring opportunities, lack of female role models, inadequate hostel facilities, unsafe transport, and gender-insensitive policies (CSIR–NIScPR, 2022). Even when women enter research, they are often underrepresented in leadership roles and bear disproportionate teaching or administrative loads, reducing research output. Third, labour market barriers reinforce attrition. Hiring biases, rigid career structures, and the "motherhood penalty" penalise women who take career breaks. Few organisations offer flexible arrangements, childcare facilities, or structured return-to-work programmes, making long-term retention difficult (CII, 2023).

Empirical research using AISHE data confirms significant disciplinary variation. Women are more visible in biological sciences and chemistry, while their participation in physics, mathematics, engineering, and information technology remains limited (Ministry of Education, 2023). International comparisons further underline these disparities: India performs relatively well in producing female science graduates, yet its performance in integrating them into research and industry careers is weaker (UNESCO, 2019).

Recent reports highlight the importance of policy and infrastructural levers in improving outcomes. Initiatives such as scholarships, hostel construction, gender audits in institutions, mentorship networks, and industry-led returnship programmes have shown promise in addressing leakages (IWWAGE, 2024; CSIR–NIScPR, 2022). However, these interventions are unevenly implemented and often lack scalability. The literature thus calls for systemic reforms that link educational participation with sustainable workforce integration, moving beyond access to address retention, progression, and leadership.

Methodology: Secondary Analysis Approach

This study adopts a secondary analysis methodology, synthesising both qualitative and quantitative evidence from published sources between 2018 and 2025. The primary databases and reports consulted include the *All India Survey on Higher Education (AISHE) 2021–22* and related releases from the Ministry of Education (Education.gov.in), UNESCO's global syntheses on women in STEM and UIS researcher statistics, as well as policy-oriented reports from think-tanks and NGOs such as IWWAGE, the Confederation of Indian Industry (CII), and the Observer Research Foundation (ORF). Peer-reviewed scholarly articles and policy briefs on gender disparities in education-to-work transitions were also reviewed.

The analysis focused on extracting indicators such as women's share of enrolment in higher education, discipline-wise STEM participation, workforce representation, and attrition points across the academic–employment pipeline. Thematic synthesis was employed to identify recurrent structural, sociocultural, and institutional barriers.

Limitations include dependence on secondary data quality, temporal lags in AISHE reporting, and challenges in cross-country comparability.

Key Findings

Educational participation: gains, but uneven across disciplines

Women's enrolment in higher education has shown consistent growth in India. According to the *All India Survey on Higher Education (AISHE) 2021–22*, total female enrolment reached approximately 2.07 crore, representing nearly 49% of total enrolments (Ministry of Education, 2023). This indicates steady progress toward gender parity in higher education overall. However, disciplinary variations are stark (Sivakumar & Usha, 2013). Women are relatively well represented in life sciences, chemistry, and medicine but remain underrepresented in engineering, computer science, and other applied technology disciplines (IWWAGE, 2024).

This pattern mirrors global data. UNESCO reports that women comprise about one-third of STEM graduates worldwide and less than 30% of researchers, with little change over the past decade (UNESCO, 2019). The disparity suggests that enrolment growth has not automatically translated into gender equity across all scientific domains. Instead, entrenched stereotypes continue to position engineering and physical sciences as "male" domains, steering women into fields perceived as more "compatible" with caregiving roles.

The education-to-workforce gap ("leaky pipeline")

The most persistent problem identified in the literature is the "leaky pipeline," whereby women exit the STEM pathway at successive stages. Although India has one of the highest proportions of women STEM graduates globally, only a fraction enters and remain in STEM careers. Industry analysts estimate that women constitute 14–30% of the STEM workforce depending on the field (CII, 2023). Attrition is particularly pronounced during transitions from postgraduate education to doctoral study, from PhD to postdoctoral positions, and from academia into industry or research and development (R&D) careers (ORF, 2021).

Marriage, mobility restrictions, and family-care responsibilities often coincide with these career stages, intensifying dropouts. The mismatch between women's high educational attainment and low representation in research and industry underscores structural inefficiencies and wasted human capital (Ramesh Kumar, et al. 2020).

Sociocultural constraints and gender norms

Sociocultural expectations remain powerful determinants of women's STEM participation. Gender norms influence subject choices, career aspirations, and the extent to which families encourage long-term professional engagement. Studies indicate that safety concerns, societal expectations around marriage, and domestic caregiving responsibilities constrain women's opportunities, particularly in careers requiring relocation, long working hours, or field assignments (IWWAGE, 2024).

Parental attitudes play a decisive role, as many families prefer daughters to select "safe" or "family-friendly" disciplines rather than technical fields perceived as male-dominated. This self-selection effect reinforces occupational segregation and restricts women's access to high-paying and innovation-intensive STEM jobs.

Institutional barriers within education and research settings

Institutional structures within higher education and research organisations often reinforce gender disparities. The lack of female role models among faculty, limited access to mentoring networks, and inadequate infrastructure—such as safe hostels, reliable transport, and on-campus childcare—contribute to attrition (CSIR–NIScPR, 2022).

Furthermore, implicit biases in admissions, research funding allocation, and professional evaluations disadvantage women. Female faculty are often concentrated in teaching-focused roles, with disproportionate administrative responsibilities, reducing time for research and publication (NIScPR, 2022). Leadership positions in academia remain male-dominated, limiting women's influence on institutional culture and policy.

Labour market factors: hiring, retention, and progression

The STEM labour market is characterised by structural biases that hinder women's progression. Studies highlight persistent wage gaps, discriminatory hiring practices, and a rigid "ideal worker" model that assumes uninterrupted career trajectories (CII, 2023). For women, career breaks for childbirth or caregiving often result in the "motherhood penalty," with reduced opportunities for advancement, pay increases, and leadership roles.

Flexible working arrangements, part-time opportunities, and re-entry or "returnship" programmes remain limited across India's STEM sectors. While some corporations have adopted diversity initiatives, their effectiveness varies, and accountability mechanisms are often weak. Without systemic change, attrition of mid-career women in STEM will remain a major barrier to gender equity.

Intersectionality: class, caste, region, and rural/urban divides

National averages often obscure inequalities across social groups. Women from urban, upper-caste, and middle-class families are more likely to access elite STEM institutions and scholarships, whereas women from rural, lower-caste, and economically disadvantaged backgrounds face additional structural barriers (IWWAGE, 2024).

These include limited access to quality secondary schooling, financial constraints, inadequate transport facilities, and social restrictions. Intersectional disadvantages compound the challenges already faced by women in STEM, suggesting that "one-size-fits-all" interventions are insufficient. Policy measures must therefore be context-sensitive, addressing regional and social inequities to expand inclusivity across the STEM ecosystem.

Discussion: Interpreting the Barriers

The persistence of gender disparities in STEM in India cannot be attributed to a single cause; rather, it reflects the interplay of educational, institutional, labour market, and sociocultural dynamics. Three interrelated factors emerge as particularly consequential.

- **Pipeline saturation at critical nodes:** While women's participation at the undergraduate level is improving in several disciplines, attrition is evident at later stages such as postgraduate specialisation, doctoral enrolment, and entry into research or industry positions. These "leaky pipeline" points suggest that blanket enrolment quotas are insufficient. Instead, targeted measures – such as doctoral fellowships, re-entry schemes, and structured mentoring – are required to address specific transition bottlenecks (Ministry of Education, 2023).
- **Institutional inertia and culture:** Academic and industrial STEM settings frequently operate on assumptions of uninterrupted, time-intensive career trajectories, a model less compatible with caregiving responsibilities disproportionately borne by women. Research highlights how implicit biases in research funding, limited female leadership, and inadequate campus infrastructure further discourage persistence in STEM careers (CSIR–NIScPR,

2022). Without organisational reform – including gender-sensitive evaluation metrics, parental leave, and flexible work arrangements – structural inequities will continue.

- **Macro policy versus micro practice:** India has launched numerous initiatives to support women in STEM, including scholarships, girls' science promotion schemes, and innovation fellowships. However, the impact of these policies is contingent on micro-level practices such as the availability of safe transport, childcare facilities, workplace mentoring, and employer incentives. Evidence suggests that without alignment between national policy frameworks and local institutional practices, policy intent often fails to translate into lived equity (ORF, 2021).

Overall, bridging the gender gap in STEM requires multi-level coordination: systemic reforms in education and labour markets, institutional culture change, and sociocultural shifts that normalise women's sustained participation in technical fields.

Policy and Practice Recommendations

Based on the secondary evidence, the following strategies are recommended, grouped by education, institutional reform and labour market measures.

Education and pipeline interventions

- **Early-stage STEM encouragement:** Expand evidence-based outreach to girls in middle and secondary school (STEM clubs, olympiads, hands-on labs) to demystify technical disciplines and provide role models.
- **Scholarships and fellowship bridges:** Provide targeted fellowships for women at transition points (UG→PG, PG→PhD) and for women returning from career breaks to re-enter research or technical careers.
- **Data disaggregation and monitoring:** AISHE and other data systems should publish discipline-wise, gender-wise and intersectional indicators (caste, rural/urban) regularly to track where leakages occur.

Institutional reforms (universities and research organisations)

- **Gender-sensitive hiring and promotion policies:** Institutions should adopt transparent hiring criteria that value career breaks fairly, implement bias training for selection committees, and set aspirational targets for female faculty recruitment and leadership.
- **Mentoring and networks:** Establish formal mentoring programmes pairing early-career women with senior researchers and create peer networks for women in STEM.
- **Infrastructure investment:** Expand safe hostels, guaranteed transport, on-campus childcare and lactation rooms to reduce attrition due to infrastructural deficits.

Labour market and employer actions

- **Flexible career pathways:** Encourage industry adoption of flexible hours, hybrid work, job-sharing and part-time R&D positions to accommodate diverse life stages.
- **Return-to-work and re-skilling programmes:** Create structured "returnship" programmes with training and re-orientation for women who took career breaks.
- **Incentivise gender-balanced recruitment:** Government procurement and research grants can incentivise gender diversity by favouring institutions and firms with demonstrable equity practices.

Societal and cultural shifts

- **Public campaigns and male engagement:** National media campaigns should normalise women's presence in technical leadership, and programmes should actively involve men as allies to redistribute care responsibilities.
- **Localised interventions:** Recognise regional and community specificities—rural-oriented scholarship schemes, transport solutions and local mentorship networks can overcome place-based barriers.

Case Examples of Promising Approaches

Several promising initiatives illustrate pathways to improving women's participation in STEM in India.

- **Institutional gender audits and targets.** Select universities and research institutions have begun conducting gender audits to track recruitment, retention, and promotion outcomes. These audits, alongside hiring targets, help identify structural bottlenecks and guide reforms in faculty recruitment and mentoring. Evidence suggests that such audits not only raise awareness but also provide actionable benchmarks for institutional accountability (CSIR–NIScPR, 2022).
- **Industry returnship models.** In the private sector, a growing number of technology firms and startups have introduced "returnship" programmes designed to help women re-enter STEM careers after career breaks. These schemes combine short-term training with structured re-entry opportunities. Early evaluations indicate improvements in re-entry rates and confidence levels, though sustaining long-term career growth requires stronger employer commitment and integration into mainstream hiring and promotion systems (CII Technology, 2021).

Together, these examples highlight scalable mechanisms for bridging India's STEM gender gap.

Conclusion

Women's participation in STEM in India has advanced in recent decades, reflected in higher enrolments and improved performance in several scientific disciplines. Yet, persistent inequalities – most evident in engineering, technology, research careers, and leadership positions – underscore that progress is uneven. Evidence from secondary sources confirms that the gender gap is driven by a "leaky pipeline," where sociocultural expectations, institutional barriers, and labour market rigidities intersect to hinder women's long-term participation (Sivakumar, 2016).

Addressing these challenges requires multi-pronged strategies. Scholarships, mentoring, and targeted outreach can expand access, while institutional reforms – gender-sensitive hiring, improved infrastructure, and leadership opportunities – can support retention (Sivakumar & Manimekalai, 2021). At the workforce level, flexible career models and structured returnship programmes are crucial to counter career breaks. Finally, societal campaigns that challenge stereotypes, alongside routine, disaggregated data collection, are essential for identifying high-impact interventions. Sustained, coordinated action across education, industry, and policy domains will be key to realising gender-equitable STEM participation in India.

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References

1. All India Survey on Higher Education (AISHE). (2021). Higher Education Statistics Report 2020-21. Ministry of Education, Government of India.
2. AICTE Handbook (2012-13). Faculty norms- prescribed by AICTE for various programmes. http://www.satiengg.in/PDF/Faculty_Norms_AICTE.pdf.
3. Confederation of Indian Industry (CII). *Women in STEM Report*. New Delhi, 2023.
4. CSIR–NIScPR. (2022). *Initiatives for Empowering Women in Science & Technology*. New Delhi.
5. IWWAGE (Institute for What Works to Advance Gender Equality). (2024). Women in STEM Challenges and Opportunities in India. https://iwwage.org/wp-content/uploads/2024/02/Women-in-STEM Challenges-and-Opportunities-in-India-Report.pdf
6. Ministry of Education (2023). *All India Survey on Higher Education (AISHE) 2021–22.* Government of India.
7. Mukhopadhyay, C. C. (1994). Family structure and Indian women's participation in science and engineering. In C. C. Mukhopadhyay, & S. Seymour (Eds.), Women, education and family structure in India (pp. 103–134) Westview Press.
8. Ramesh Kumar, K., Sivakumar, I., Saravanakumar, N., & Sathishkumar, R. (2020). Regional Disparities and Indian States: A Macro Level Study, *Journal of Critical Reviews*, 7(13), 87-92.
9. Observer Research Foundation (ORF) (2021). *Women and STEM: The Inexplicable Gap Between Education and Workforce Participation.* New Delhi.
10. Sivakumar, I. & Manimekalai, K. (2021). Masculinity and Challenges for Women in Indian Culture. Journal of International Women's Studies, 22(5), 427-436.
11. Sivakumar, I. (2016). Gender Mainstreaming as a Tool for Women Empowerment, *Indian Journal of Women's Studies,* 9(1), 53-59.
12. Sivakumar, I., & Usha, V.T. (2013). Education and Women in India: In Theoretical Perspective, *Development and Displacement: Social Justice Paradigm* (eds), APH: New Delhi, 141-148.
13. UNESCO. (2019). Cracking the code: Girls' and women's education in STEM. United Nations Educational, Scientific and Cultural Organization.
14. UN (2002). Gender mainstreaming. An overview. UN. https://www.un.org/womenwatch/osagi/ pdf/e65237.pdf.
15. Women in S & T: A vision document (2016). Inter-academy panel on 'women in science' in India. Women in S & T: A vision document. http://nasi.nic.in/Report%20-%20Women%20in% 20Science%20&%20Technology%20-A%20Vision%20Document.pdf.