

WOMEN IN STEM: CHALLENGES AND OPPORTUNITIES IN THE 21ST CENTURY

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Abstract: Women's participation in Science, Technology, Engineering, and Mathematics (STEM) is crucial for global innovation and sustainable development, yet persistent inequalities continue to restrict their advancement. Despite historic contributions by pioneers such as Marie Curie and Janaki Ammal, women remain underrepresented in STEM education, research, and leadership, with UNESCO (2021) estimating their share at only 35% of global STEM students. Structural barriers—including patriarchal norms, gender stereotypes, pay gaps, workplace discrimination, and limited mentorship—create a “leaky pipeline” where many women exit before attaining senior positions. At the same time, the 21st century presents unprecedented opportunities through digitalization, artificial intelligence, remote work, and women-led startups, alongside corporate and government diversity initiatives. This study explores both the enduring challenges and the emerging possibilities for women in STEM, situating them within broader debates on equity, innovation, and sustainability. Drawing from secondary data, thematic analysis, and global case examples, it emphasizes the need for comprehensive reforms in policy, education, and workplace structures to dismantle systemic barriers and ensure women's full participation in shaping the future of STEM.

Key Words: Women in STEM, Gender Equity, Patriarchy, Innovation, Sustainable Development.

1. INTRODUCTION:

Science, Technology, Engineering, and Mathematics (STEM) fields have long been the foundation of innovation, industrial progress, and technological development. However, these fields have historically been dominated by men, leaving women significantly underrepresented. For centuries, societal norms, institutional barriers, and cultural prejudices constrained women's access to education, scientific inquiry, and professional recognition. Despite such limitations, women such as Marie Curie, Ada Lovelace, Janaki Ammal, and Rosalind Franklin paved the way for generations of aspiring women scientists and engineers, proving that talent and intellect are not bound by gender (Sivakumar & Usha, 2013).

Even in the 21st century, progress toward gender equity in STEM has been uneven. While women have achieved remarkable milestones in technology, research, and entrepreneurship, they continue to face systemic obstacles such as workplace discrimination, gender stereotypes, pay gaps, and lack of representation in leadership roles. UNESCO (2021) estimates that only 35% of STEM students worldwide are women, and their representation further declines in advanced research, faculty positions, and executive-level decision-making. The persistence of these inequalities points to deep-rooted structural challenges that cannot be solved solely through individual effort.

At the same time, the global landscape of STEM is undergoing rapid transformation. The rise of digital technologies, artificial intelligence, green innovations, and biotech advancements offers fresh opportunities for women to take leadership roles. Initiatives promoting gender inclusivity, mentorship, and supportive workplace policies are gradually reshaping the environment. More young girls are being encouraged to pursue STEM education, and women-led startups are gaining visibility and funding. Furthermore, governments and multinational corporations have started acknowledging that diversity in STEM is not just a matter of equity but also a driver of creativity, problem-solving, and innovation. This article explores the challenges that continue to restrict women's participation and advancement in STEM while also highlighting the emerging opportunities that can empower them. By examining structural barriers alongside policy initiatives, entrepreneurial trends, and educational reforms, the article emphasizes the need for a multi-pronged strategy to ensure women's full inclusion in STEM.

2. STATEMENT OF THE PROBLEM:

Despite significant progress toward gender equality in education and employment, women remain underrepresented in STEM fields worldwide. UNESCO (2021) reports that women constitute only 35% of higher education students in STEM, while their presence further declines at senior academic and leadership levels. This disparity persists due to multiple interlinked barriers, including cultural stereotypes, workplace discrimination, lack of mentorship, and systemic pay inequities. Women in STEM are often compelled to navigate hostile work environments, balancing demanding careers with disproportionate family responsibilities, which contributes to the “leaky pipeline” phenomenon—where many leave before reaching leadership roles.

At the same time, global shifts toward digitalization, artificial intelligence, and innovation-driven economies underscore the urgent need for diverse participation in STEM. While new opportunities are emerging through women-led entrepreneurship, remote work, and policy initiatives, structural inequalities prevent women from fully accessing these benefits. The underrepresentation of women not only reflects social inequity but also weakens the innovation potential of STEM industries, which thrive on diverse perspectives. The problem is therefore twofold: women continue to face barriers that restrict their advancement, while society as a whole suffers from the loss of their potential contributions. Addressing this issue is essential for inclusive and sustainable development.

3. RESEARCH GAP:

Existing research on women in STEM has primarily focused on either the barriers women face or the policy initiatives designed to promote gender equity. While these studies provide valuable insights, they often address challenges and opportunities in isolation, without integrating them into a comprehensive framework that reflects the evolving global STEM landscape. Additionally, much of the literature is concentrated on Western contexts, leaving limited comparative analysis of women’s experiences in diverse cultural and socio-economic settings.

Another gap lies in the inadequate exploration of recent developments such as the rise of women-led startups, the impact of remote work, and women’s growing participation in artificial intelligence and machine learning. These areas represent transformative shifts in STEM yet remain underexplored in academic studies. This research seeks to bridge these gaps by providing a holistic analysis of both challenges and opportunities while situating women’s participation in STEM within a broader framework of equity, innovation, and sustainability.

4. RESEARCH OBJECTIVES:

The primary objective of this research is to analyze the challenges and opportunities faced by women in STEM fields in the 21st century. Specifically, the study seeks to:

1. Examine the structural, cultural, and institutional barriers limiting women’s participation
2. Assess the impact of gender bias, pay gaps, and work-life balance struggles on women’s career trajectories;
3. Explore emerging opportunities such as women-led startups, AI participation, and inclusive workplace policies; and
4. Propose actionable recommendations for policymakers, educators, and organizations to foster greater gender equity and inclusivity in STEM careers globally.

5. RESEARCH METHODOLOGY:

This study adopts a descriptive and analytical qualitative research methodology. Secondary data forms the foundation, drawing from scholarly articles, UNESCO and World Economic Forum reports, policy documents, and industry surveys to assess women’s representation in STEM and associated challenges. The study employs thematic analysis to identify recurring issues such as gender stereotypes, workplace discrimination, and pay disparities, as well as emerging opportunities like women-led entrepreneurship, AI participation, and remote work.

A comparative approach will be used to highlight global patterns and variations across regions, with particular emphasis on both developed and developing contexts. Where available, statistical data from organizations such as the National Science Foundation, McKinsey & Company, and government initiatives will be integrated to substantiate findings. The qualitative analysis will be complemented with case examples of successful women-led STEM initiatives. The ultimate aim is to generate evidence-based recommendations that can inform policies, institutional reforms, and grassroots interventions.

6. CHALLENGES FACED BY WOMEN IN STEM :

- **Gender Stereotypes and Cultural Bias**

One of the most significant barriers for women in STEM is the persistence of gender stereotypes and cultural conditioning. From an early age, many girls are subtly or explicitly discouraged from engaging in mathematics, physics, or engineering, while being steered toward humanities or caregiving professions. These societal expectations often diminish their confidence in pursuing technical careers.

UNESCO (2021) reported that only 35% of higher education students in STEM-related disciplines are women, a figure that reveals not a lack of capability but the effect of systemic discouragement. Cultural narratives across societies reinforce the perception that women are less capable in logic-intensive or technically demanding domains. This not only reduces female enrolment in STEM but also lowers retention, as women internalize doubts about their competence.

In many countries, cultural pressures further restrict women's autonomy to choose academic and career paths. Families may prioritize sons for higher education in STEM, assuming daughters will not need such qualifications. The long-term effect of these biases is the underutilization of female potential in industries that urgently need skilled talent.

- **Lack of Female Role Models**

Representation plays a critical role in shaping aspirations. When young women do not see leaders, scientists, engineers, or entrepreneurs who resemble them, they may find it difficult to envision themselves in such positions. Women currently hold only 28% of leadership positions in technology companies (World Economic Forum, 2023).

The absence of female role models has a cascading effect: fewer women at the top means fewer mentors for younger women entering STEM careers. Moreover, media and textbooks often underrepresent historical contributions by women, further erasing role models from collective memory. This invisibility sustains the perception that STEM is "male territory."

Encouragingly, visibility campaigns, women-in-tech conferences, and digital platforms are starting to spotlight women's contributions. Yet, bridging this gap requires structural support for women's advancement into leadership roles.

- **Patriarchy as a Root Cause**

Patriarchy is a deeply entrenched socio-cultural system that privileges men and male-dominated structures while subordinating women. It shapes power relations within families, workplaces, and societies, often leading to systemic discrimination and unequal opportunities for women. Patriarchy reinforces rigid gender roles, restricting women's agency in education, career choices, and leadership (Sivakumar & Manimekalai, 2021). It manifests in wage gaps, lack of representation in decision-making bodies, and gender-based violence. In professional fields like STEM, patriarchal norms create barriers such as stereotypes that women are less competent in science and technology, limited mentorship opportunities, and hostile work environments. These structural inequalities make women's struggles not just individual challenges but systemic issues rooted in patriarchal dominance. Overcoming patriarchy requires dismantling discriminatory practices, promoting gender-sensitive policies, and fostering an inclusive culture that values women's contributions equally.

Patriarchy remains a fundamental structural barrier limiting women's advancement in STEM. Deeply entrenched patriarchal norms assign women to caregiving and domestic roles, discouraging them from pursuing education and careers in technical fields. These gendered expectations perpetuate stereotypes that STEM is a "male domain," reinforcing self-doubt and limiting institutional support for women's ambitions. Patriarchy also influences hiring decisions, pay disparities, and leadership opportunities, as workplaces often reflect the same hierarchical biases found in society. Without challenging patriarchal structures at cultural, educational, and organizational levels, efforts to achieve gender equity in STEM will remain incomplete.

- **Workplace Discrimination and Unconscious Bias**

Even when women enter STEM fields, they often face hostile or biased workplace environments. Discrimination can manifest in subtle ways, such as being overlooked for promotions, excluded from important projects, or judged more harshly for mistakes. A Harvard Business Review study (2022) found that women in STEM are 1.5 times more likely to leave their careers due to workplace bias than their male counterparts.

Unconscious bias further compounds the problem. Hiring committees, often dominated by men, may unconsciously assume women are less committed to long-term STEM careers due to family responsibilities. Such assumptions limit women's chances of securing tenure-track academic positions, technical leadership roles, or high-stakes research opportunities.

In addition, women often face a "prove-it-again" bias, where their competence must be continually revalidated, unlike men whose abilities are taken for granted. These structural disadvantages lead to attrition, creating a "leaky pipeline" effect in STEM career trajectories.

- **Work-Life Balance Challenges**

Balancing demanding STEM careers with family responsibilities presents another significant barrier. STEM careers often involve long hours, continuous learning, conference travel, and research commitments that collide with caregiving duties traditionally assigned to women.

According to McKinsey & Company (2023), over 50% of women in STEM identify work-life balance as a major challenge, prompting many to seek fewer demanding roles outside STEM. In cultures where childcare and domestic responsibilities fall disproportionately on women, the problem becomes more acute. The lack of supportive policies such as flexible schedules, parental leave, and affordable childcare reduces women's capacity to sustain long-term STEM careers.

This challenge underscores the need for systemic change, as women should not have to choose between professional aspirations and personal responsibilities.

- **Gender Pay Gap**

Despite their qualifications and contributions, women in STEM consistently earn less than men. The U.S. Bureau of Labor Statistics (2023) reported that women in STEM earn about 82 cents for every dollar earned by men. The gender pay gap not only reduces women's lifetime earnings but also diminishes the perceived value of their work.

Pay disparities discourage women from staying in competitive STEM careers. Even when women achieve similar educational levels and job roles, they are often offered lower starting salaries and receive smaller raises compared to men. Addressing wage inequality requires transparency in pay structures, stronger regulatory frameworks, and organizational accountability.

- **Harassment and Hostile Work Environments**

Harassment remains a pervasive issue in STEM workplaces. A National Academies of Sciences report (2021) found that 50% of women in STEM in the U.S. experienced some form of sexual harassment. Hostile work cultures not only affect women's psychological well-being but also reduce productivity, collaboration, and retention.

Toxic environments discourage women from pursuing long-term careers in STEM. Beyond direct harassment, the lack of institutional mechanisms to report grievances without fear of retaliation exacerbates the problem. For women of colour and other marginalized identities, the intersection of gender and racial discrimination intensifies the challenges.

7. OPPORTUNITIES FOR WOMEN IN STEM:

- **Rise in Women-Led Startups**

In recent years, women have been breaking into STEM entrepreneurship, leading startups that harness technology to address real-world problems. According to PitchBook (2023), venture capital funding for women-led tech startups grew by 20% in the last five years. This increase reflects a growing recognition of women as innovators and entrepreneurs.

Women-led startups often focus on socially relevant innovations, such as health-tech, ed-tech, and sustainable energy solutions. These ventures not only diversify the innovation ecosystem but also generate inclusive products that reflect diverse perspectives.

- **Increasing Participation in AI and Machine Learning**

Artificial intelligence (AI), machine learning, and data science represent some of the fastest-growing sectors in STEM, and women are increasingly carving out roles in these areas. Stanford University's AI Index Report (2023) revealed that women's participation in AI research rose from 15% in 2010 to 26% in 2023.

Mentorship initiatives, coding boot camps, and women-in-data-science networks are fostering this growth. Given the transformative potential of AI across industries, women's participation ensures that algorithmic designs are more inclusive and ethical, mitigating risks of gender-biased technologies.

- **Expansion of Remote Work**

The shift toward remote work, accelerated by the COVID-19 pandemic, has created new opportunities for women to participate in STEM careers without geographical or logistical constraints. A LinkedIn Workforce Report (2023) found that remote STEM job opportunities increased by 40% since 2020.

Remote work provides flexibility, enabling women to balance professional and personal responsibilities more effectively. It also opens global opportunities, allowing women in regions with limited STEM infrastructure to access international projects and collaborations.

- **Corporate and Government DEI Initiatives**

Governments and corporations increasingly recognize that gender diversity in STEM is not merely a moral imperative but also an economic necessity. The European Commission's Women in Digital Scoreboard (2023) documented a 12% increase in female participation in STEM careers over the last decade due to targeted initiatives.

Multinational companies such as Google, IBM, and Microsoft have launched diversity-focused recruitment, mentorship, and leadership training programs. Government schemes, including scholarships, STEM fellowships, and startup grants for women, further expand opportunities (Ramesh Kumar et al, 2020).

- **STEM Education for Girls**

Encouraging girls to pursue STEM education from an early age is key to bridging the gender gap. Programs such as Girls Who Code, the United Nations Girls' Education Initiative (2023), and various national campaigns have successfully raised female enrolment in STEM subjects. Countries with targeted programs have seen up to a 30% increase in female STEM graduates.

Early interventions challenge stereotypes before they solidify, building confidence among girls and normalizing their presence in STEM classrooms. Curriculum reforms that highlight contributions of women scientists further strengthen the pipeline.

- **Growing Investment in Women-Led Research**

Funding for women-led research is increasing globally. The National Science Foundation (2023) reported an 18% rise in funding allocated to projects led by female researchers. Such investments are crucial in ensuring that women have the resources to pursue groundbreaking work, publish extensively, and ascend to leadership roles in academia and industry.

Supporting women-led research not only ensures fairness but also diversifies the research agenda. Women often bring new perspectives to problem-solving, which enriches scientific discovery and expands societal benefits.

8. CONCLUSION AND RECOMMENDATIONS:

Women in STEM today face a paradoxical landscape: while systemic barriers such as stereotypes, bias, and harassment persist, unprecedented opportunities are also emerging through entrepreneurship, AI, remote work, and inclusive policy frameworks. The future of STEM depends on harnessing the talents of all individuals, regardless of gender. Ensuring women's full participation is not simply an ethical goal but a necessity for global competitiveness and innovation (Sivakumar, 2016).

To accelerate gender equity in STEM, the following recommendations are essential:

- **Policy Reforms** – Governments should mandate equal pay transparency, strengthen anti-harassment laws, and provide financial incentives for organizations that demonstrate gender equity.
- **Education and Outreach** – Curricula must incorporate female contributions to science and actively promote girls' participation in STEM subjects from primary education onward.
- **Mentorship and Networking** – Structured mentorship programs should pair early-career women with established professionals, ensuring guidance and sponsorship.
- **Workplace Flexibility** – Employers should implement flexible hours, remote options, and parental leave to support work-life balance.

- **Visibility Campaigns** – Media and academic institutions should highlight stories of women leaders in STEM to normalize female excellence in these fields.
- **Sustained Investment** – Governments, corporations, and philanthropic organizations should expand funding for women-led startups, innovations, and research.

Creating a more inclusive STEM ecosystem will require collective action from policymakers, educators, corporations, and society at large. By dismantling systemic barriers and expanding opportunities, the world can move toward a future where women are not only participants but also leaders shaping the next era of scientific and technological advancement.

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