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Exploring the Roadblocks: A Review of Factors Affecting Women in STEM Education and Careers

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Abstract: ***This paper examines the key factors influencing women's education and career choices in STEM (Science, Technology, Engineering, and Mathematics) education. Despite increasing emphasis on STEM fields globally, women remain underrepresented in these disciplines due to a complex interplay of psychological, social, and institutional barriers. Through an analysis of existing literature, this study explores critical determinants such as self-esteem, self-efficacy, perceived social support, and perceptions. The review also highlights the impact of early exposure to STEM, family and peer influences, and the role of educational practices in shaping women's academic interests and career aspirations. By synthesizing current research, the paper identifies gaps and suggests strategies for promoting gender equity in STEM education and professions. The findings aim to inform educators, policymakers, and stakeholders committed to fostering an inclusive environment that encourages and sustains women's participation and success in STEM careers.***

Keywords: Women in STEM, STEM Education, Perception, Self-Esteem, Self-Efficacy, Perceived Support.

I. INTRODUCTION

Education has traditionally been viewed as a process of transmission—pouring knowledge into passive recipients. However, contemporary approaches recognize it as a dynamic process that fosters experiential learning, critical thinking, and the development of desirable behaviors (Darling-Hammond et al., 2020). In India, the National Education Policy (NEP) 2020, approved by the Union Cabinet on July 29, 2020, marked a transformative step in this direction. Replacing the 1986 National Policy on Education, NEP 2020 envisions an equitable, inclusive, and vibrant knowledge society by ensuring high-quality education for all (Government of India, 2020). A key component of this vision is fostering holistic, enjoyable, and engaging learning environments—especially in fields like Science, Technology, Engineering, and Mathematics (STEM). Rayle, Arredondo, and Kurpius (2005) found that higher self-esteem among college females was associated with a stronger valuation of education and lower academic stress, underscoring the role of psychological well-being in educational outcomes. In contrast, Gatta and Trigg (2001) revealed that many women hold the belief that they are unlikely to succeed in science or technology careers, a perception that significantly limits their participation in STEM fields. The challenge is not merely one of individual choice but of structural inequality. As Clewell, Cosentino de Cohen, Tsui, et al. (2005) emphasize, increasing women's involvement in STEM is critical to building a balanced and innovative workforce. The exclusion of women from STEM limits not only their personal and economic opportunities but also undermines national growth, competitiveness, and scientific

advancement (UNESCO, 2021). International comparisons further illustrate the need for urgent action. According to Wei (2006), while the United States, with a population of approximately 300 million, produces around 60,000 engineers annually, India graduates 350,000 engineers and China 600,000 each year—far outpacing the U.S. on a per capita basis. However, more recent analyses stress that quantity alone is not sufficient; quality, gender diversity, and employability are equally critical for national progress in the Fourth Industrial Revolution (World Economic Forum, 2023).

Therefore, addressing the factors that hinder women's participation in STEM—such as low self-efficacy, lack of role models, gender stereotypes, and limited access to quality education—is essential. Empowering women through inclusive and equitable STEM education not only promotes gender equality but also enhances national productivity, innovation, and long-term development.

II. Literature Review

The acronym STEM—encompassing Science, Technology, Engineering, and Mathematics—has gained increasing prominence in global policy discourse, particularly in relation to industrial innovation, research development, higher education enrollment, and school curricula (Marginson et al., 2013). In today's fast-paced and technologically driven global economy, national progress is increasingly contingent upon the cultivation of a highly skilled workforce, especially in the areas of technology and engineering. STEM education is widely recognized as a vital framework for developing the advanced problem-solving and future-ready competencies essential for success in these fields. El Nagdi (2018) emphasizes that STEM education functions not only as a pedagogical approach to mastering complex academic content but also as a preparatory mechanism for meeting the demands of an evolving professional landscape. Its flexible, interdisciplinary, and globally relevant nature makes it suitable across a range of educational contexts. Similarly, Deemer, Tims, Corbett, and Mhire (2014), through their study associated with the Cyber Security Education and Training Assistance Program (CETAP), demonstrate a strong connection between STEM education and career readiness. Their findings highlight that proficiency in STEM disciplines—when integrated with mechanical reasoning and essential soft skills such as communication—significantly enhances employability, particularly in emerging sectors like cyber security. Despite the clear advantages of STEM education, gender disparities in participation remain a pressing concern. Women continue to be underrepresented in both STEM academic pathways and professional roles, particularly in technology and engineering domains. Marcus (2000) reported that women made up only 25% of systems analysts and fewer than 30% of programmers, while Reed-Jenkins (2003) found that women accounted for just 11% of engineers and 16% of architects. These figures point to enduring systemic obstacles that limit women's engagement in STEM disciplines. In response to these disparities, McKenna (2016) explored strategies for creating meaningful connections between female students and STEM education. Her study suggests that targeted professional development initiatives for educators can contribute to more inclusive and supportive learning environments, ultimately fostering greater female participation in STEM subjects.

a) Perceptions

Students' attitudes and levels of engagement toward mathematics and related disciplines are widely recognized as crucial drivers for promoting interdisciplinary learning within STEM education. Values not only influence students' responses to STEM subjects but are also shaped and reinforced through their exposure to these subjects (Schreiner & Sjøberg, 2007). Among the most persistent barriers to women's participation in STEM are gender stereotypes, which significantly influence perception and interest. As noted by Cheryan et al. (2017), prevailing societal beliefs that align STEM fields with masculine traits often discourage girls from identifying with these domains. From an early age, girls are subtly guided toward traditionally "feminine" academic paths, reinforcing the misconception that STEM is not appropriate for them (Eccles, 2009).

Exposure to STEM-related experiences and role models plays a pivotal role in shaping young women's perceptions and aspirations. Wang and Degol (2017) emphasize that engaging classroom environments, hands-on activities, and teacher encouragement can significantly increase girls' interest and participation in STEM. In contrast, the absence of female role

models and the presence of gender-biased teaching practices can undermine self-confidence and hinder the development of a strong academic identity in STEM fields (Dasgupta & Stout, 2014).

Furthermore, the perception of limited career prospects, the prevalence of gender-based discrimination, and insufficient institutional support structures further diminish women's sustained engagement in STEM education and careers. Research by Blickenstaff (2005) and UNESCO (2017) underscores the ongoing institutional and structural challenges that perpetuate gender disparities across both educational and professional STEM education.

b) Self-esteem

Self-esteem, conceptualized as an individual's overall perception of personal worth and self-acceptance (Rosenberg, 1965), has been widely examined for its impact on academic performance and career aspirations. Within the realm of STEM (Science, Technology, Engineering, and Mathematics) education, self-esteem emerges as a critical factor influencing women's participation, persistence, and achievement. Numerous studies have highlighted that self-esteem significantly affects motivation, academic resilience, and the development of a STEM-related identity, particularly for female students. Rayle, Arredondo, and Kurpius (2005) found that higher self-esteem in college women was positively associated with a stronger appreciation for education and reduced academic stress. Similarly, Lent, Brown, and Hackett (2000) argued that self-esteem enhances students' engagement with STEM subjects and their ability to persevere through academic challenges, thereby increasing the likelihood of pursuing STEM careers. In contrast, lower self-esteem has been linked to self-doubt, fear of failure, and the tendency to avoid rigorous STEM coursework (Seymour & Hewitt, 1997). Gatta and Trigg (2001) observed that many women perceive themselves as unlikely to succeed in science or technology-related careers. This negative self-perception contributes significantly to the ongoing underrepresentation of women in these fields, thus limiting the equitable development of a diverse workforce. The internalization of gender stereotypes further undermines female students' confidence, particularly in male-dominated environments, where the risk of stereotype threat is heightened (Nix, Perez-Felkner, & Thomas, 2015). Baumeister, Campbell, Krueger, and Vohs (2003) reviewed existing research and suggested that while high self-esteem does not necessarily predict academic excellence, it is often an outcome of prior academic success. They cautioned that artificially boosting self-esteem does not automatically improve academic outcomes. Nonetheless, fostering a genuine sense of self-worth remains vital for women's sustained interest and confidence in STEM. Finally, implicit biases continue to shape women's self-concepts in these disciplines. According to Nosek et al. (2009), the unconscious association of science with masculinity contributes to diminished self-esteem among women in STEM, thereby influencing their academic and career choices. These findings underscore the need for supportive interventions that build self-esteem and challenge limiting gender norms within STEM education.

c) Self-efficacy

Self-efficacy, defined by Margolis and McCabe (2006) as an individual's belief in their capacity to succeed in specific tasks or related areas, plays a pivotal role in academic and career decision-making, particularly in the context of STEM (Science, Technology, Engineering, and Mathematics) education. It influences not only students' performance but also their motivation, persistence, and long-term engagement in challenging fields. Rayle, Arredondo, and Kurpius (2005) conducted a study on 530 female undergraduates and found that women who, along with their families, placed a high value on education tended to exhibit stronger educational self-efficacy. This aligns with earlier findings by Gloria and Robinson-Kurpius (2001), which confirmed that educational self-efficacy is a powerful predictor of academic persistence among female students. Bandura's (1997) theory of self-efficacy underscores the importance of belief in one's abilities as a determinant of both academic success and career aspirations. In the STEM context, this belief becomes particularly critical. Zeldin and Pajares (2000) discovered that women often underestimate their abilities in STEM, despite demonstrating performance levels comparable to their male counterparts. This underestimation can lead to reduced motivation, disengagement, and a diminished likelihood of pursuing STEM careers. Huang (2013) further supported these findings, noting that gender-based discrepancies in

self-efficacy are not reflective of actual ability but are influenced by pervasive stereotypes and a lack of female representation in STEM. Moreover, Cheryan et al. (2017) emphasized that gender norms and the underrepresentation of women in STEM roles contribute to lower self-efficacy among girls and young women. These internalized beliefs often lead to a cycle of reduced confidence and limited participation in STEM-related learning opportunities. Empirical studies have also shown that when educational environments incorporate strategies that build self-efficacy—such as project-based learning and problem-solving approaches—students, particularly women, feel more empowered. Ahmad, Hewlett, and Williamowski (2010) demonstrated that integrating logic instruction within STEM education using web-based and project-based learning environments enhanced students' ability to approach and solve complex tasks, thereby boosting self-efficacy. Importantly, women with higher self-efficacy in STEM subjects are more likely to overcome challenges, persist through academic hurdles, and envision long-term careers in STEM fields. For instance, Nix, Perez-Felkner, and Thomas (2015) found that perceived self-efficacy in mathematics significantly influenced women's decisions to pursue STEM majors in college. In sum, self-efficacy is a key psychological construct that directly shapes women's engagement, achievement, and persistence in STEM education. Addressing gendered biases and fostering supportive learning environments are essential strategies for enhancing self-efficacy among female STEM learners.

d) Perceived social support

Social support plays a critical role in shaping students' educational experiences and outcomes, particularly for women pursuing STEM (Science, Technology, Engineering, and Mathematics) fields. It can be understood both as the actual support received and the perceived availability of support, encompassing sources such as family members, peers, teachers, counselors, and mentors. Numerous studies have linked social support to improved coping mechanisms and reduced stress levels, which are essential for academic persistence. However, women often report receiving less encouragement for educational pursuits compared to their male counterparts. Rayle et al. (2001) observed that women frequently perceive lower levels of support, which can negatively affect their academic engagement. Leaper (2015) emphasized the role of parental encouragement—especially from mothers—in positively influencing girls' attitudes toward science and mathematics. In contrast, peer dynamics can sometimes exert a counterproductive influence; the need for social acceptance may lead young women to avoid STEM subjects that are stereotypically seen as socially isolating or male-dominated. Efforts to bridge the gender gap in STEM have led to promising interventions. Programs such as girls-only STEM camps, mentorship initiatives, and the integration of gender-sensitive curricula have shown potential in improving perceptions and increasing female participation (Hill, Corbett, & St. Rose, 2010). Nonetheless, long-term progress depends on broader societal changes and sustained policy efforts that normalize and support women's inclusion in STEM. Family support and peer relationships continue to be strong predictors of women's interest and success in STEM education. Girls who report high levels of parental encouragement are more likely to express enthusiasm for STEM careers (Leaper, 2015). Likewise, supportive peer networks can enhance a sense of belonging, which is particularly crucial in male-dominated academic settings (Wang & Degol, 2017). Furthermore, faculty and mentor support significantly influences women's self-confidence and academic commitment. Mentorship from female STEM professionals helps reduce feelings of isolation and fosters engagement and persistence (Dennehy & Dasgupta, 2017). Faculty practices that emphasize inclusion, recognize women's contributions, and offer personalized encouragement are linked to higher retention and achievement among female STEM students (Fouad et al., 2010).

III. RECOMMENDATIONS

To encourage more women to pursue STEM education in higher education and consider STEM careers, educational institutions must adopt gender-sensitive pedagogies that actively promote gender equity. This includes using inclusive language, integrating STEM examples relevant to diverse contexts, and dismantling gender stereotypes within the classroom environment. Early exposure to STEM is also critical; therefore, schools should introduce STEM concepts through hands-on activities, provide female role models, and engage girls in problem-solving tasks from a young age to foster sustained interest.

Furthermore, establishing formal mentoring programs that connect female students with women professionals and faculty in STEM can significantly enhance their self-efficacy, confidence, and academic persistence. Family and community engagement play a pivotal role as well; awareness programs aimed at parents and communities should emphasize the importance of supporting girls' education and participation in STEM, with particular focus on parental encouragement, especially from mothers. Additionally, higher education institutions should build supportive peer networks, women-in-STEM clubs, and faculty-led initiatives to provide emotional, academic, and social support, helping female students feel a strong sense of belonging in often male-dominated fields. Offering workshops focused on self-efficacy and confidence building, including resilience training and strategies to overcome stereotype threat, can empower women to navigate challenges more effectively. Finally, policy-level interventions are essential, requiring policymakers to implement scholarship schemes, enforce gender-equity mandates, and establish institutional accountability measures that encourage and monitor women's participation in STEM education and careers. Together, these steps can create a more inclusive, supportive environment that motivates and sustains women's involvement in STEM disciplines at higher education levels and beyond.

IV. Suggestions

Research on women in STEM education and careers should consider conducting studies that track the development of self-esteem and self-efficacy among female STEM students over time. This approach would provide deeper understanding of how these factors evolve and influence their academic progress and career decisions. Additionally, there is a need for intersectional analysis that examines how other social identities—such as socioeconomic status, and geographic location—interact with gender to shape women's experiences and challenges in pursuing STEM education and careers. Evaluating the effectiveness of intervention programs, such as mentorship initiatives, STEM camps, and policy measures, is also crucial to understand their real impact on the enrollment, retention, and success of women in STEM fields. Moreover, studies should explore the role of digital and online learning environments in shaping women's STEM education experiences, especially for those in under-resourced or rural areas, to identify opportunities for increasing access and boosting self-efficacy. Finally, comparative research across different cultures and regions would be valuable in uncovering how cultural contexts influence gender disparities in STEM education and career choices, thereby informing more culturally responsive strategies to support women in these fields.

V. Conclusion

This study highlights the critical role that various psychological and social factors—such as self-esteem, self-efficacy, and perceived support—play in shaping women's participation and success in STEM education and careers. Despite the growing recognition of STEM fields as essential to economic and technological advancement, significant gender disparities persist due to deeply ingrained stereotypes, lack of role models, and insufficient support systems. Addressing these challenges requires a multifaceted approach that includes gender-sensitive teaching practices, early exposure to STEM, mentorship programs, and stronger family and community engagement. Empowering women through confidence-building initiatives and policy interventions can foster greater persistence and achievement in STEM disciplines. Ultimately, promoting an inclusive and supportive environment is essential for closing the gender gap and enabling women to fully contribute to and benefit from opportunities in STEM education and careers.

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