

Navigating the Glass Ceiling in Engineering: Overcoming Gender Bias

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Abstract

Despite decades of progress, women in engineering continue to face the “glass ceiling,” encountering persistent gender bias, cultural barriers, and limited access to leadership opportunities. This paper traces the historical roots of these inequities and examines their contemporary impact on women’s career choices, retention, advancement, and leadership representation in STEM fields. Drawing on existing literature and empirical findings from previous studies, the paper explores how structural barriers, male-dominated cultures, and intersectional factors shape women’s experiences throughout their educational and professional journeys. Emphasizing the transformative role of mentorship, visible role models, inclusive organizational policies, and advocacy efforts in promoting gender equity and fostering a sense of belonging. By offering practical recommendations for educators, employers, and policymakers, the paper illuminates the urgent need to dismantle systemic barriers, empower women, and cultivate a more diverse, equitable, and innovative engineering profession.

Keywords: Women in Engineering, Glass Ceiling, Gender Bias, Career Advancement, STEM Diversity, Leadership, Inclusive Practices

Introduction

The issue of gender bias and the glass ceiling in engineering is a complex problem with deep historical roots. For instance, [1] refer to the barriers women face in the engineering career pathway as the glass ceiling. The Glass ceiling is an analogy that describes obstacles women encounter when navigating career path regardless of their qualifications or accomplishments. Despite numerous efforts over the past three decades, a significant gender gap persists in the fields of technology, engineering, and physical sciences. It is crucial to prioritize the development of a more diverse workforce, with a particular focus on achieving a better gender balance. This is essential to ensure that women are equipped with the necessary skills to meet the demands of the future [13]. To fully grasp the present challenges and possibilities for change in engineering education, we must go back to the historical context and explore its implications for the present day [10]. The paper seeks to explore the struggles women face while pursuing careers in engineering.

Historical Background

Historically, Engineering has long been a male-dominated field, a reflection of broader societal gender norms. Women seeking careers in engineering were often met with skepticism and resistance [4],[6]. Their participation was limited, and their accomplishments were often overlooked. [9] argues that normative preservation of engineering masculinity in the 20th century had clear structural barriers and cultural norms against women participating in the discipline of engineering. Women were not admitted to study engineering, they were not given jobs in engineering, they were constrained from all but a very few professions [3]. For instance, in 1955, Eric Walker, Penn State University's engineering dean, wrote a column saying, "Women are NOT For Engineering." Walker declared that most women did not have the "basic capabilities" needed for engineering [3]. He concluded that teaching them did not make sense; since the most evident ambition of many women is to get married and raise a family.

As World War II concluded, a wave of male veterans enrolls in American engineering programs, making the end of wartime urgency to encourage women in developing technical field [7]. Furthermore, conservative gender norms of the postwar era reinforced prevailing belief that women should prioritize marriages and families over pursuing career ambitions. Women who expressed interests in engineering were discouraged by family or educators [3]. However, brave women have challenged these norms throughout history [4]. Notable figures like Lillian Gilbreth, the pioneering industrial engineer and psychologist, and Edith Clarke, the first female electrical engineer, broke new ground [3].

By challenging and overcoming societal barriers, these women paved the way for more inclusive and diverse landscape within the engineering field, leaving a permanent mark on the profession.

Current Representation Statistics

Even though women have constituted majority of individuals obtaining medical and health science degrees and pursuing careers in these fields in the United States in recent years, their representation remains disproportionately low in the STEM disciplines, particularly those that require a high level of mathematical proficiency [14]. According to [8] Women obtained only 29% of doctorates in mathematics and statistics, 19% in computer and information sciences, 23% in engineering, and 34% in physical and technological sciences. In contrast, women account for 54% of all earned doctorates in biological and biomedical sciences, as well as 48% of all earned medical degrees. The presented figures indicate that disciplines requiring a strong emphasis on mathematics is among the few areas within the STEM fields where gender parity between men and women has not yet been achieved. The above statistics are an indication of the underrepresentation of women in STEM disciplines that are consider male dominant, despite their competency, willingness, and contributions to these STEM sectors over the years.

The Impact of Barriers on Women's Underrepresentation in STEM Field

The underrepresentation of women in STEM disciplines has significant effects that have wide-ranging implications. Firstly, if a woman does not choose to pursue a career in one of the STEM fields, she may be passing on a wide variety of professional prospects in addition to potential financial benefits. This choice has the potential to restrict their own potential while simultaneously having a detrimental effect on the expansion of the economy [15]. Secondly, the lack of diversity in STEM fields is largely due to insufficient participation of women. Consequently, the pace of technological progress and intellectual development is hindered [16].

Due to a lack of diversity in the STEM profession, there is a restriction placed on the breadth of viewpoints and original ideas that have the potential to contribute to the fields of science and technology. Thirdly, the presence of gender gaps in STEM fields carries significant economic implications for the world. Lastly, the issue of inequality arises from the persistent underrepresentation of women, which contributes to sustaining gender-based disparities and reinforce societal prejudices that restrict women's access to specific professions and businesses.

Factors Contributing to the Glass Ceiling

Several studies have been conducted to explore the issues of women participation in engineering. For example, [12] rely on literature review and content analysis as their research methods to synthesize existing research findings and the theoretical framework of belongingness theory, social identity theory, and self-determination theory to explore women's experiences in engineering. These theories help to understand the experiences of women in engineering by providing insights into their sense of belonging, how they identify with their gender and engineering community, and their motivation and self-determination within the field. It provides a broader historical and theoretical perspective, examining the persistence of gender disparities in engineering, and discusses the broader cultural transformation needed within engineering to create a gender-balanced environment. [11] employed quantitative research methods, including surveys, multiple linear regression analysis, and categorization by engineering discipline to collect and analyze numerical data from first-year female engineering students. These methods were chosen to investigate differences in attitudes and career goals across various engineering disciplines by employing social norm theory, feminist theory, career choice theory, and identity theory to understand women's attitudes and goals in choosing engineering disciplines. These frameworks provide the foundation for analyzing and interpreting the data and findings in each respective and form the basis for analyzing women's attitudes and goals within the engineering discipline.

Despite the differences in methodologies and theoretical framework, [11] and [12] shared the same goals of addressing gender disparities in engineering. These two articles offer a multifaceted perspective on gender diversity in engineering by addressing gender disparities and the challenges women face in engineering. They emphasized the importance of achieving gender diversity in engineering and its benefits for the field, society, and women's career opportunities. Similarly, they acknowledge the influence of intersectional factors, such as race and ethnicity, on women's experiences and representation in engineering. As [12] unveiled, women in engineering face significant challenges related to developing a sense of belonging within the field. As a female, my personal journey and struggles, attest to this. Attending a university with no female instructor or role model, I had to question my own belonging in engineering and so was the case of many female students. Some of the challenges highlighted by both studies linked to gender identity threats, male dominance, and cultural norms. These are all component of the glass ceiling women navigate in pursuit of a career in engineering. At times it contributes to shifting women's career goals. [11] claimed that social norms and gender representation within specific engineering disciplines significantly shape female engineering students' attitudes and career goals.

These challenges as mentioned above are among the potential factors that are contributing to the lower retention rates and higher attrition among women in engineering thus becoming a global challenge. The need to create a more inclusive environment for female in engineering cannot be over emphasized. Creating an inclusive engineering environment, it is imperative to conduct thorough research on female in engineering at all level and experiences. This highlights the importance of recognizing these disciplinary differences when addressing gender disparities in engineering. As [12] emphasizes, efforts to increase women's participation in engineering must go beyond addressing structural barriers and focus on creating a more inclusive and welcoming environment.

Navigating the glass ceiling in engineering is a global challenge that warrants consistent efforts and attention within the engineering community to ensure that sustainable development goals (SDG'S) on gender equality are achieved.

Current state of the glass ceiling

The lessons drawn from history hold significant implications for addressing gender bias in engineering today. Firstly, it indicates persistence in bias. Despite progress, gender bias endures in various forms, including stereotypes, unequal opportunities, and underrepresentation of women in leadership roles. Acknowledging this bias is very important for change. Secondly, it highlights the importance of role models and mentorship.

The historical figures who broke barriers serve as inspiration for today's female engineers, demonstrating that access to mentorship and visible role models can contribute to the empowerment of the next generation of women in engineering. Furthermore, the past teaches us that diversity in engineering is not just moral imperatives but also drivers of innovation and progress. Diverse teams bring fresh perspectives and creative solutions from varied backgrounds and experiences to the table, fostering an environment where fresh ideas can flourish [5].

By incorporating a range of perspectives, it does not only enhance the quality of decision-making but also promotes a culture of continuous learning, which is a key element in navigating an involving landscape of professional and innovative journeys. Finally, through advocacy and awareness, history reminds us that change is possible.

Conclusion

Throughout history, women have suffered greatly to make their way through STEM career paths. The historical context of gender bias in engineering offers insights for addressing this issue in the present day. Women have striven for equal opportunities and recognition in engineering for generations, making significant strides. Navigating the glass ceiling demands our unwavering commitment to breaking barriers and fostering a supportive environment for all. As we strive for equality and empower each other, let our collective efforts shatter the glass, paving the way for a future where opportunities are bound for every individual, regardless of gender. Navigating the glass ceiling in engineering is a journey that benefits from recognizing the past while steering towards a future where gender bias is no longer an obstacle.

The resilience and accomplishments of women in engineering have set the pace for awareness about gender bias in engineering, which can initiate transformative shifts through collective action, education, and commitment, which will enable women to break free from the biases and create a more equitable future for the next generation.

Recommendations

There is an urgent need to create a more inclusive environment for women in

engineering. To overcome the challenges posed by the glass ceiling, it is important for employers, academic institutions, industries, etc. to engage in the following activities:

- I. Actively work with educational institutions to create diverse and inclusive environments that will value and celebrate differences. This includes fostering safe spaces where women feel respected, heard, and empowered to thrive.
- II. Establish mentorship initiatives to support women in their career progression (e.g., peer mentors at colleges and workplaces). This is because peer and professional mentoring programs can help women in engineering navigate academic and career challenges, build confidence, and make informed decisions about their professional paths.
- III. Ensure that promotions, opportunities, and recognition are based on merit rather than gender. Transparent evaluation systems should be implemented with clear performance metrics to reduce bias in decision-making. By rewarding individuals based on their skills, achievements, and contributions, institutions can promote fairness and increase motivation.
- IV. Invest in educational programs that encourage girls and young women to pursue careers in traditionally male-dominated fields, because early exposure is critical. Initiatives such as K-12 STEM outreach programs, Children STEM Books, workshops, and hands-on learning experiences can spark interest and build confidence. These programs help challenge stereotypes and expand career possibilities for young women.
- V. Introduce flexible policies to accommodate the diverse needs of employees; Flexible work arrangements, such as remote work, parental leave, and adaptable schedules 'allow women to balance personal and professional responsibilities. These policies are especially important for retaining talent and supporting inclusivity in the workplace.
- VI. Develop leadership development programs aimed at women aspiring to leadership roles, focusing on building essential skills such as communication, decision-making, and strategic thinking. By equipping women with the confidence and tools needed to navigate organizational structures and institutions can cultivate a more diverse and effective leadership pipeline.

In addition, employers should encourage and support women to attend conferences and Become active members of professional organizations, such as the Society of Women Engineers (SWE), to enhance networking, mentorship, and career development.

By actively working to implement these recommendations, we can collectively work towards tearing down the glass ceiling and create workplaces that are equitable, diverse, and supportive.

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