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ADVANCING GENDER DIVERSITY: THE ROLE AND IMPACT OF WOMEN IN ENGINEERING

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Purpose: This article explores the role and impact of women in engineering, highlighting how increasing gender diversity can drive innovation and contribute to the overall success of the engineering sector. The participation of women in engineering not only addresses workforce gaps but also fosters inclusive work environments that encourage diverse perspectives in problem-solving and product development.
Design/methodology/approach: A comprehensive literature review and analysis of industry reports were conducted to examine the structural and social factors influencing gender diversity in engineering.
Findings: The study reveals that while progress has been made in promoting gender diversity, women remain underrepresented in engineering roles. However, their contributions lead to improved team dynamics, innovative solutions, and stronger organizational performance. Additionally, the presence of women in leadership positions enhances organizational culture and encourages mentorship and support for future female engineers.
Research limitations/implications: Efforts to advance gender diversity in engineering must address challenges such as gender bias, workplace culture, and career development opportunities. Ensuring a supportive and inclusive environment is essential for retaining and advancing women in engineering roles.
Practical implications: The paper highlights strategies for organizations to foster gender diversity, including targeted recruitment efforts, mentorship programs, and creating a culture that values diversity.
Originality/value: This article provides actionable insights and strategic guidance for engineering firms aiming to enhance gender diversity and benefit from the unique contributions women bring to the field. It is especially valuable for companies seeking to improve innovation and inclusivity through diverse workforces.
Keywords: Gender Diversity, Women in Engineering, Innovation, Workforce Inclusion.
Category of the paper: This article reviews the factors affecting gender diversity in engineering and explores the benefits and challenges of fostering an inclusive workforce.

1. Introduction

Engineering, a field traditionally dominated by men, has undergone significant transformation in recent decades, with an increasing emphasis on gender diversity and inclusion. The growing recognition of the underrepresentation of women in engineering has prompted numerous studies and initiatives aimed at fostering diversity, not only to address equity concerns but also to enhance the performance, creativity, and innovation capacity of engineering teams (Avolio, 2020). The benefits of gender diversity in the workplace are well documented; diverse teams are more likely to offer a wider range of perspectives, leading to more robust problem-solving and innovative solutions. In engineering, where complex, interdisciplinary challenges are the norm, the inclusion of women can play a critical role in broadening the scope of design and technological advancements (Casad, 2021). Despite this progress, the underrepresentation of women in engineering remains a persistent global issue. According to UNESCO (2021), women constitute only 28% of the global engineering workforce, with notable regional disparities. In countries with more progressive gender policies, such as those in Western Europe, women's representation is somewhat higher, yet still below parity, while in regions like the Middle East and South Asia, women's participation in engineering is particularly low. This gender gap can be traced to a variety of socio-cultural, educational, and institutional factors, including gender stereotypes, lack of female role models, and systemic biases in both academic and professional settings (Verdugo-Castro, 2022). The literature on this topic has increasingly focused on addressing these barriers and identifying strategies to support and retain women in engineering careers (Makarem, 2020).

Historically, gender stereotypes have significantly influenced the perception of engineering as a "male" profession (Tabassum, 2021). Engineering has been associated with traits traditionally viewed as masculine, such as technical proficiency, problem-solving, and hands-on work. This perception has discouraged many women from pursuing engineering as a viable career path, despite their equal capability in these areas. Research by Cheryan et al. (2017) suggests that societal stereotypes about gender and technical ability begin in childhood and are reinforced throughout education, contributing to the lower enrollment of women in engineering programs at universities. These gendered perceptions not only affect young women's choices but also create environments within engineering education and workplaces that may feel unwelcoming or even hostile to female engineers (O'Connell, 2021).

Education, therefore, plays a crucial role in both perpetuating and challenging these gender disparities (Kuchynka, 2022). Numerous studies point to the importance of early exposure to STEM (Science, Technology, Engineering, and Mathematics) subjects as a way to mitigate the impact of gender stereotypes. Interventions such as mentorship programs, gender-sensitive curricula, and outreach initiatives that specifically target girls and young women have shown promise in increasing female participation in engineering (Kuteesa, 2024). For instance,

programs that introduce girls to engineering concepts through hands-on, practical experiences, such as robotics clubs or coding workshops, have been found to increase interest and confidence in engineering fields (Master, Cheryan, Meltzoff, 2016). Furthermore, female role models in engineering play a crucial role in shaping the aspirations of young women. Studies have demonstrated that when women see others like themselves succeeding in the field, they are more likely to envisage engineering as a potential career path (O'Connell, 2021).

The workplace culture within engineering organizations also poses significant challenges for women (O'Connor, 2020). Women engineers often report feeling isolated or excluded in male-dominated environments, and gender biases in recruitment, promotion, and salary negotiation persist. Studies by Fouad and Singh (2011) indicate that women are more likely than their male counterparts to leave engineering careers, citing reasons such as lack of advancement opportunities, hostile work environments, and work-life balance difficulties. This phenomenon, often referred to as the "leaky pipeline", highlights the need for structural reforms within engineering companies and institutions to retain women and foster inclusive work environments (Gregor, 2023). Initiatives such as flexible work policies, unconscious bias training, and diversity and inclusion programs are becoming increasingly prevalent in addressing these issues. Moreover, advocacy for more female leadership in engineering is gaining momentum, as research consistently shows that women in leadership positions can drive cultural change and serve as role models for the next generation of female engineers (Holtzblatt, 2021).

2. Literature Review

Diversity and inclusion in the workplace have become critical areas of focus across multiple sectors, particularly in industries that thrive on innovation, such as engineering, technology, and manufacturing (Snowball, 2022). Research increasingly demonstrates that diverse teams are better positioned to approach problems with creativity, adaptability, and a broader range of perspectives, ultimately leading to more innovative solutions (Hundschell, 2022). Gender diversity, in particular, has been shown to positively impact organizational performance, enhancing profitability, productivity, and overall team dynamics (Martinez-Jimenez, 2020). This literature review explores key studies and reports on diversity, innovation, and workforce inclusion, emphasizing the need for greater gender diversity in engineering and related fields.

One of the most significant contributions of diversity to innovation is the way in which it fosters a variety of perspectives. Homogeneous teams, while often more comfortable in terms of collaboration, tend to approach problems from similar viewpoints, which can limit creativity. Homan et al. (2020) emphasize that gender-diverse teams are more likely to challenge conventional thinking and offer unique solutions, which is particularly important in sectors like

engineering that deal with complex, interdisciplinary challenges. This creative problem-solving is further enhanced when diverse teams are placed in inclusive environments that encourage open communication and the free exchange of ideas (Leroy, 2022). Numerous studies have highlighted the economic benefits of gender diversity, particularly in leadership roles. The World Economic Forum (2022) reports that companies with higher gender diversity in leadership outperform those with less diversity in terms of profitability and productivity. These companies are better able to navigate volatile markets, adapt to changing demands, and implement innovative strategies (Wilk, 2020). Gender diversity in leadership also sets a tone for the broader organizational culture, promoting inclusion and encouraging a more diverse talent pool to rise within the ranks (Makarem, 2024). Despite the clear advantages of gender diversity, women remain significantly underrepresented in engineering, one of the most innovation-dependent fields. UNESCO (2023) found that women account for only 28% of the global engineering workforce. Moreover, fewer women pursue advanced degrees in engineering, and those who do are less likely to occupy leadership roles compared to men (Ross, 2022). This discrepancy is often attributed to a variety of factors, including deep-seated gender biases and stereotypes that suggest women are less suited for STEM (Science, Technology, Engineering, and Mathematics) careers. These biases not only affect hiring and promotion practices but also contribute to a lack of visible female role models in the field (Tandrayen, 2022). Cultural and structural barriers continue to impede the advancement of women in engineering (Swafford, 2020). Gender biases in hiring, promotion, and performance evaluations are well-documented, with many women reporting that they feel undervalued or overlooked for key opportunities (Kong, 2020). These biases are often unconscious but deeply ingrained, reflecting broader societal norms that associate technical and leadership capabilities with masculinity. In addition to these biases, workplace cultures in engineering are often described as unwelcoming or even hostile to women, contributing to higher turnover rates among female engineers (Gonzalez-Perez, 2022). Addressing these barriers requires systemic changes at multiple levels. Educational institutions, for example, play a crucial role in shaping perceptions of engineering as a viable career path for women (Makarem, 2020). Early exposure to STEM education, gender-inclusive curricula, and targeted outreach programs can help encourage more girls and young women to pursue engineering. Mentorship programs that connect female students with professional engineers have also been shown to boost confidence and interest in engineering careers (Guenaga, 2022). Furthermore, companies must adopt more inclusive hiring and promotion practices, invest in unconscious bias training, and create environments where diverse talent can thrive (Woods, 2021). Workplace inclusion is another key factor in retaining women in engineering. Inclusive environments are those where all employees feel valued, heard, and empowered to contribute their ideas (Shore, 2022). In such settings, diverse teams are not only more likely to innovate but also more likely to succeed in implementing their ideas. This is especially important in engineering, where collaboration across disciplines is often essential to solving complex problems. Inclusion initiatives such as flexible work policies,

diversity and inclusion training, and the promotion of female leadership can help address many of the challenges women face in the workplace. As Homan et al. (2020) point out, the success of diverse teams hinges on the extent to which organizations create inclusive environments that support collaboration and open dialogue. The global demand for engineers is rising rapidly, driven by technological advancements and societal challenges such as climate change. Engineering is crucial to addressing these challenges, but the shortage of skilled engineers, combined with the underrepresentation of women in the field, presents a significant obstacle (Lekchiri, 2020). By improving gender diversity, companies can tap into a wider talent pool, bridge the skills gap, and foster the innovation necessary to meet future workforce needs. Encouraging more women to enter and remain in engineering is not only a matter of equity but also a practical strategy for driving innovation and ensuring long-term competitiveness in the global market (Ventura, 2021). In conclusion, the literature on diversity, innovation, and workforce inclusion clearly demonstrates the significant advantages of gender diversity in engineering and other innovation-dependent fields. While progress has been made, substantial barriers to the advancement of women in engineering persist, including gender biases, stereotypes, and exclusionary workplace cultures (Schmader, 2023). Addressing these challenges requires a comprehensive approach involving educational reform, corporate responsibility, and societal change. Only through continued efforts to create more inclusive and diverse environments can the full potential of gender diversity be realized, ultimately driving greater innovation and success in engineering and beyond (Helman, 2020). Additionally, workplace culture in many engineering firms is often described as being male-centric, which can contribute to feelings of isolation among women engineers (Smith, 2020). This culture is often perpetuated by the lack of diversity in leadership positions, where women are vastly underrepresented. According to the Society of Women Engineers (2023), women hold less than 15% of managerial positions in engineering firms globally. Another significant barrier is the work-life balance challenge, which disproportionately affects women, especially those with caregiving responsibilities. Engineering, like many other technical professions, is often associated with long hours and demanding project schedules, which can discourage women from entering or staying in the profession (Rosa, 2022). The "leaky pipeline" phenomenon, where women exit the field at various career stages, is particularly pronounced in engineering (Park, 2023). Women in engineering are more likely than their male counterparts to leave the profession mid-career due to a lack of support for work-life balance, limited opportunities for advancement, and hostile work environments. In recent years, there has been a concerted effort from both academic institutions and industry to address these challenges and promote gender diversity in engineering (Casad, 2021). Many engineering schools have implemented programs aimed at increasing the enrollment and retention of women in STEM disciplines. For instance, universities are creating mentorship programs that connect female students with successful women engineers, providing them with role models and support networks to help them navigate

their academic and professional journeys (Gartstein, 2021). Industry reports from leading engineering firms also indicate a growing commitment to diversity and inclusion initiatives.

The advancement of women in engineering is not only a matter of equity but also a strategic imperative for the industry (Bonet, 2020). Increasing gender diversity can drive innovation, enhance team performance, and help address the growing demand for skilled engineers. While progress has been made in recent years, significant barriers remain, particularly in terms of workplace culture, career advancement opportunities, and work-life balance (Rashmi, 2022).

3. Methodology

This study employs a literature review approach and analysis of industry reports. According to Paul and Criado (2020), there are three types of reviews: domain-based, theory-based, and method-based. The approach taken here aligns with the domain-based review, which synthesizes and expands upon literature within a specific field or topic (Palmatier et al., 2018). The data for this review comes from various sources, including company reports, news articles, and institutional databases. Notably, there are no strict methodological limitations on how the data is analyzed. This research focuses of companies such as: Siemens, General Electric, Lockheed Martin, and BAE Systems. Companies like Siemens, General Electric, and Lockheed Martin, which have launched diversity programs that include gender diversity targets, unconscious bias training for managers, and flexible work policies designed to improve work-life balance (Engineering UK, 2023). These programs are aimed at not only recruiting more women into engineering roles but also creating a supportive environment where they can thrive and advance in their careers. Despite these initiatives, progress remains slow, and many challenges persist. A 2023 report by McKinsey & Company notes that while many organizations have made public commitments to diversity, the actual representation of women in technical and leadership roles has seen only modest increases. The report highlights the need for more comprehensive and sustained efforts, including policy changes, to address the root causes of gender inequality in engineering.

Siemens (www. siemens.com) is a global technology powerhouse founded in 1847, in Berlin, Germany, by Werner von Siemens. Initially focused on telegraph technology, Siemens has since expanded into a wide range of industries, including energy, automation, healthcare, and transportation. The company is known for its innovation in electrification, automation, and digitalization, providing advanced solutions in industrial manufacturing and infrastructure. Siemens has a strong commitment to sustainability and diversity, with a major focus on digital transformation across its operations.

General Electric (GE) was founded in 1892 by Thomas Edison and Charles Coffin, combining Edison's various businesses into a corporation. Headquartered in Boston, Massachusetts, GE has been a leader in industries such as energy, aviation, healthcare, and power systems (www.ge.com). The company has played a key role in shaping modern technologies, from early electrical innovations to advanced jet engines and medical imaging equipment. GE is known for its commitment to innovation and corporate sustainability, as well as fostering diversity in technical roles.

Lockheed Martin (www.lockheedmartin.com) is an American aerospace, defence, and security company formed in 1995 from the merger of Lockheed Corporation and Martin Marietta. Headquartered in Bethesda, Maryland, Lockheed Martin is one of the largest defence contractors in the world, specializing in the development and production of advanced technology systems, including military aircraft, missiles, and space exploration technologies. The company plays a key role in U.S. defence and aerospace innovation, supporting a wide range of government and civilian projects.

BAE Systems, founded in 1999, is a British multinational defence, aerospace, and security company based in London. It was formed through the merger of British Aerospace and Marconi Electronic Systems. BAE Systems is a leading global defence contractor, known for its work in military aircraft, naval vessels, submarines, and advanced electronics systems. The company serves governments' commercial customers worldwide, playing a crucial role in defence innovation and security technologies. BAE Systems is also actively working on gender diversity and sustainability initiatives across its workforce (www.baesystems.com).

4. Findings

Siemens has demonstrated a strong commitment to improving gender diversity, particularly within its engineering divisions. According to Siemens' 2023 Annual Diversity and Inclusion Report (www.siemens.com), the company has set ambitious targets to increase the representation of women in leadership positions. Siemens aims to have women occupy 30% of its leadership roles by 2025, a significant step towards achieving gender parity at the highest levels of the organization. To support this goal, Siemens has implemented targeted recruitment and mentorship programs specifically designed for women in STEM fields. These programs are intended to attract, retain, and promote female talent within the company. For example, Siemens has established initiatives that focus on identifying and nurturing women with high potential in engineering and other technical roles. By providing tailored mentorship and professional development opportunities, Siemens seeks to address the systemic barriers that have historically hindered women's advancement in engineering. Moreover, Siemens actively promotes

an inclusive culture through its Siemens Diversity Charter. This charter is a comprehensive framework aimed at ensuring equal opportunities for all employees, regardless of gender, background, or identity. It outlines the company's commitment to fostering a workplace where diversity is valued and where all employees feel included and supported. The charter serves as a guiding document for Siemens' diversity and inclusion strategies, ensuring that efforts to promote gender equality are embedded in the company's corporate culture and practices. Siemens' flexible working policies also play a crucial role in supporting gender diversity. The company offers remote work options and family-friendly hours, which are particularly beneficial for women balancing career and caregiving responsibilities. These policies are designed to create a more accommodating work environment, helping employees manage their professional and personal lives more effectively. The positive impact of these policies has been recognized by independent organizations, with Siemens being listed among the top companies for gender equality in engineering by Forbes in 2023. This recognition underscores the effectiveness of Siemens' strategies in promoting a more inclusive and supportive workplace.

General Electric's Balance the Equation initiative (www.ge.com), launched in 2021, represents a significant commitment to increasing the number of women in technical roles across the company. GE has set ambitious goals, including a target of having 20,000 women in STEM roles by 2030 and achieving gender parity in engineering positions by 2050. These targets reflect GE's recognition of the critical role that gender diversity plays in driving innovation and maintaining a competitive edge in the industry. To support these goals, GE has developed a range of internal programs focused on attracting and developing female talent. One such program is the Women's Network, an internal platform designed to connect female employees with mentors and sponsors who can provide guidance and support throughout their careers. This network facilitates professional development and helps women navigate the challenges associated with advancing in technical fields. GE's commitment to diversity is also reflected in its recruiting policies, which prioritize hiring from a diverse talent pool. The company partners with universities and organizations such as the Society of Women Engineers (SWE) to encourage more women to pursue STEM education and careers. These partnerships help create a pipeline of female talent and support the development of the next generation of engineers. The effectiveness of GE's diversity initiatives is evident in its 2022 diversity report, which shows a 5% increase in female technical hires compared to the previous year. This increase highlights the success of GE's efforts to attract and retain women in engineering roles. By focusing on both recruitment and development, GE is making significant strides towards achieving its diversity goals and ensuring that women have equal opportunities to succeed in technical careers.

Lockheed Martin (www.lockheedmartin.com) is another leading company making notable progress in gender diversity within its engineering divisions. The company has set a target of achieving 25% female representation in engineering roles by 2030. To reach this goal, Lockheed Martin has implemented a variety of programs and initiatives aimed at supporting

women in engineering. One of Lockheed Martin's key initiatives is the Women in Engineering program, which provides development opportunities through leadership training, mentorship, and networking events. This program is designed to help women advance in their careers and overcome the barriers that have historically limited their progress in engineering. By offering targeted support and professional development, Lockheed Martin aims to increase the number of women in senior engineering positions. Lockheed Martin also actively partners with educational institutions to support young women pursuing engineering degrees. The company's STEM Scholarship Program, launched in 2018, provides financial support to students from underrepresented backgrounds, including women, who are studying in STEM fields. This program helps alleviate the financial burden associated with higher education and encourages more women to pursue engineering careers. The Lockheed Women's Impact Network, an internal resource group, promotes dialogue and career advancement opportunities for female employees. This network fosters an inclusive and supportive workplace environment, where women can connect with peers, mentors, and leaders to advance their careers. Additionally, Lockheed Martin's Inclusion Pledge focuses on addressing gender bias within the workplace. This pledge includes regular training for managers on unconscious bias and revising policies to ensure equal opportunities in hiring and promotions.

BAE Systems (www.baesystems.com) is committed to increasing the representation of women in technical roles, with a goal of achieving a 50% increase by 2030. The company's diversity strategy is built around three key pillars: attracting more women to STEM, retaining female engineers by fostering an inclusive work environment, and providing development opportunities for women at all levels. One of BAE's notable initiatives is the Returners Program, which supports women who have taken career breaks and wish to return to the engineering profession. This program provides tailored training and flexible working arrangements to ease the transition back into the workforce. By addressing the unique challenges faced by women returning to work, BAE Systems helps facilitate their reintegration and supports their continued career development. Additionally, BAE's STEM Ambassadors initiative involves female engineers visiting schools to encourage young girls to consider engineering careers. This program aims to inspire the next generation of female engineers and address the gender gap at an early stage. By actively engaging with students and promoting engineering as a viable career path for women, BAE Systems helps build a more diverse talent pipeline for the future. BAE Systems tracks its progress through annual diversity reports, which show steady growth in the number of women in engineering roles. According to the company's 2023 diversity report, women now make up 18% of the engineering workforce, up from 14% in 2020. This increase reflects the effectiveness of BAE's diversity initiatives and its commitment to fostering a more inclusive engineering workforce.

5. Discussion

Women have significantly contributed to the engineering field, bringing diverse perspectives and skills that drive innovation. Research indicates that gender-diverse teams tend to outperform homogenous teams in problem-solving and creativity. For example, Homan (2021) highlight how teams with a higher percentage of women often demonstrate enhanced problem-solving abilities and more innovative solutions. This is attributed to diverse viewpoints that challenge conventional thinking and lead to more comprehensive and creative approaches to engineering problems. The inclusion of women in engineering not only promotes a more balanced representation but also contributes to better business outcomes. According to the World Economic Forum (2022), gender diversity in leadership roles correlates with improved financial performance and organizational effectiveness. Companies with diverse engineering teams are better positioned to address the needs of a broader customer base and to adapt to changing market demands.

Despite the positive impacts, women in engineering face several challenges that can hinder their career advancement. Stereotypes and biases remain prevalent, influencing hiring practices, promotion opportunities, and workplace culture. Tandrayen (2022) discusses how gender biases and societal stereotypes discourage women from pursuing engineering careers and contribute to the "leaky pipeline" phenomenon, where women drop out of engineering fields at higher rates than their male counterparts. Additionally, the lack of female role models and mentors in engineering can limit career progression for women. Park (2023) analyzes factors leading to career attrition among women in engineering, highlighting that inadequate support and mentorship are significant contributors. This lack of guidance can result in lower retention rates and fewer women advancing to senior technical and leadership positions. Work-life balance is another critical issue. Many women in engineering struggle to manage professional responsibilities alongside personal and family commitments. Policies that support flexible working arrangements and family leave are crucial but often insufficiently implemented. The challenges of balancing these demands can lead to higher attrition rates and lower overall job satisfaction among female engineers.

The ongoing efforts to improve gender diversity in engineering have several implications for the industry. Firstly, there is a growing recognition of the need for systemic change within organizations. Initiatives such as targeted recruitment, mentorship programs, and diversity training are essential to address the barriers faced by women in engineering. For example, companies like Siemens and General Electric have implemented comprehensive diversity programs aimed at increasing female representation in technical roles (Siemens Annual Diversity and Inclusion Report, 2023; General Electric, Balance the Equation Report, 2022). Moreover, there is an increasing emphasis on creating supportive and inclusive work environments. Organizations are investing in policies and practices that promote work-life

balance, such as flexible work hours and remote work options. These measures are crucial for retaining female engineers and ensuring their continued success and satisfaction within the industry.

While the existing literature provides valuable insights into the role and impact of women in engineering (Agurto, 2021), there are limitations that should be acknowledged. Many studies rely on self-reported data, which can introduce bias and affect the accuracy of the findings (Russo, 2020). Additionally, research often focuses on specific regions or sectors, which may not fully represent the global engineering landscape. There is also a need for longitudinal studies to track the long-term impacts of gender diversity initiatives. Short-term studies may not capture the sustained effects of diversity programs or the evolving challenges faced by women in engineering. Furthermore, while much research highlights the barriers and challenges, there is less focus on the effectiveness of various interventions and their real-world outcomes.

To address these limitations, future research should aim to include diverse and longitudinal data to provide a more comprehensive understanding of gender diversity in engineering. Studies should also explore the effectiveness of different diversity initiatives and policies, assessing their impact on both individual career outcomes and organizational performance. Additionally, there is a need for more research on intersectionality, examining how factors such as race, ethnicity, and socioeconomic background intersect with gender to affect experiences in engineering (Campbell-Montalvo, 2022). This will help create more nuanced and effective strategies for promoting diversity and inclusion in the field.

Advancing gender diversity in engineering is not only a matter of equity but also a strategic advantage for organizations. Women bring valuable perspectives and skills that enhance innovation and performance (Tahir, 2021). However, significant challenges remain, including biases, lack of mentorship, and work-life balance issues. Addressing these challenges requires systemic changes within organizations and continued research to develop and evaluate effective diversity initiatives. By overcoming these barriers and fostering an inclusive environment, the engineering industry can unlock its full potential and drive greater success and innovation (Opstad, 2024).

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