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Review

Bridging gaps: the intersection of women in engineering and gender studies—challenges, advances, and future directions

Daniel Raphael Ejike Ewim[1,2] · **Akinola George Dosunmu**[1,2]

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Abstract
Despite growing awareness, the underrepresentation of women in the engineering profession remains a persistent global issue, reflecting broader gender inequalities in STEM fields. This paper explores the intersection of women and engineering, employing a gender study lens to synthesize existing research and analyze challenges, initiatives, and future directions in this context. It contextualizes systemic barriers such as implicit biases, gendered stereotypes, and the sticky wall phenomenon, as well as intersectional dimensions impacting marginalized groups. The paper evaluates organizational policies, educational reforms, and workplace strategies to foster inclusivity for women in the sciences. By integrating insights from gender studies, the analysis highlights critical gaps in the current literature. It proposes inclusive strategies to advance the equity and representation of women in the engineering profession. This study seeks to guide future research and inform policy implementation through a multidisciplinary approach, promoting diversity and inclusivity in engineering professions worldwide.

Keywords Gender · Equity · Women in engineering · Diversity · Inclusion · Intersectionality

1 Introduction

Gender inequality in engineering is a persistent and multifaceted issue that reflects broader societal imbalances in science, technology, engineering, and mathematics (STEM) [4]. Despite decades of advocacy, women continue to be underrepresented in engineering, comprising a minority in academia and professional workplaces [33]. This disparity extends beyond mere numbers but encompasses systemic barriers, including implicit biases, gendered stereotypes, and organizational cultures that often marginalize women. The intersection of gender studies and engineering provides a valuable lens through which to analyze these barriers, offering critical insights into the structural and cultural dynamics that sustain such inequalities [32].

The experiences of the multifaceted identities of women in engineering professions are connected to developing strategies that promote a truly equitable and inclusive environment [52]. Thus, gender studies and diversity in engineering enrich the profession with a range of innovations, creativity, and perspectives and enhance problem-solving capabilities, thus leading to greater engineering outcomes. Researchers have demonstrated that gender composition varies in terms of outperforming diverse counterparts related to performance, innovation, and decision-making [8]. Thus, prioritizing gender studies is not only a matter of equity but also an imperative strategy for advancing the field of engineering.

✉ Akinola George Dosunmu, akinola_dosunmu@yahoo.com | [1]Department of Mechanical Engineering, Durban University of Technology, Durban, South Africa. [2]Department of Adult Community and Continuing Education, University of South Africa, Pretoria, South Africa.

Therefore, gender studies, with their focus on power dynamics, identity, and intersectionality, offer insights into understanding and addressing the persistent gender gap in engineering. However, by integrating theories and findings from this field of study, we can critically illuminate the implicit and explicit mechanisms that perpetuate inequalities in science professions. Moreover, this multidisciplinary approach enables a deeper exploration and understanding of how these factors disproportionately impact women from marginalized backgrounds, including those facing racial, socioeconomic, or other intersectional disadvantages.

However, understanding the intersection of women in engineering and gender studies is important for multiple reasons. From an educational perspective, fostering greater inclusion in engineering disciplines ensures that a more diverse range of individual talent enters the workforce [37]. In terms of policy, understanding the challenges experienced by women professionals can inform the development of equitable organizational practices, recruitment strategies, and retention initiatives. For industry and workplace practices, addressing gender inequality can enhance innovation and productivity by drawing from a wider array of perspectives and experiences [22].

This study emphasizes the need for an interdisciplinary approach to address the gender gap effectively in the engineering profession. Traditional efforts to promote diversity, equity, and inclusivity have often focused on isolated interventions, such as increasing representation in educational settings or creating mentoring programs. While these initiatives are valuable, they are insufficient to address the deeply entrenched cultural, structural, and systemic barriers. Integrating insights from the perspective of gender studies provides a comprehensive framework to analyze and deconstruct these challenges while proposing inclusive strategies for transformation. The question underpinning this research is what hinders women's inequalities and the intersection of gender in the engineering field. However, this study aims to analyze the underrepresentation of women in the engineering profession by examining its intersection with gender studies.

2 Contextual issues and theoretical frameworks

Historically, the engineering field has been dominated by men, with a significant underrepresentation of women. As the field has evolved and continues to grow, addressing the challenges faced by women who are interested in pursuing careers in the engineering field has become increasingly important. These challenges include low encouragement, gender biases, and negative experiences that discourage women from entering and remaining in the field [46]. However, the literature critically argues for the intersectionality of women and gender studies in the engineering profession as a discourse shaped by historical antecedents in this field/discipline. We have argued for a transformation of these tenets through our research of systematic literature reviews related to this phenomenon, which have historically created challenges for women who struggle to break through the sticky walls that have impeded them from striving, particularly in the engineering field/profession. This argument led to contextualizing the Applied Sciences in Engineering (ASE) programs that place a strong emphasis on interdisciplinary hands-on education [13]. Obviously, in recent decades, women have been underrepresented in engineering professions, thus indicating a widening gap in terms of women's representation and participation in this field. This discourse, as part of our systematic literature review related to the topic, has been contextualized to argue that ASE programs provide opportunities for women to have access to various engineering programs. However, the question is how this program approaches and bridges the gender gap in terms of the intersectionality of women in engineering and gender studies. Therefore, this study provides an understanding of how the ASE approach prepares women for the challenges of the engineering industry and helps them thrive in this profession. However, equality is still questioned in this context.

These contextual issues, as debated, show that the ASE program has recently attracted the attention of women in interdisciplinary engineering studies in terms of the remarkable success of a high percentage of women in various engineering disciplines/fields. Our study argues for this particular trend, highlighting the underrepresentation of women in engineering fields and thus showing how this program can provide valuable insights for promoting equity and diversity in engineering education. However, these trends in terms of the inclusion of women in engineering studies have been argued to be essential owing to the unique experiences and perspectives they bring, highlighting the importance of achieving equity in this field. The idea of equity policy implementation in the engineering profession field is to create an unbiased opportunity for women who intend to pursue and/or build careers in this field. However, we argued that the range of broader perspectives in terms of embracing women in engineering and other STEM professions will ultimately drive economic development, challenge stereotypes and biases, provide role models and mentorship, and expand talent pools. In addition to these arguments, women's perspectives have been considered to make equity in the engineering profession/disciplines crucial for achieving progress and sustainable solutions and development in society.

The movement of women professionals in the engineering profession has been noticeable slowly but is argued to be a slightly significant development, with persistent challenges still impeding full equity [53]. Historically, engineering has been male dominated and rooted in industrial practices and societal norms that exclude women from such technical professions. In the early twentieth century, women's participation in the engineering profession was minimal and was thus limited largely to supportive roles or niche areas deemed socially acceptable, such as textiles and chemical engineering [20]. However, World War II marked a provisional paradigm shift as women were recruited into engineering roles to fill labor shortages, but this progress was reversed after the war, when traditional gender norms were reinstated. It is argued that it was not until the latter half of the twentieth century that more substantial strides were made, driven by the civil rights movement and feminist advocacy [16]. Thus, initiatives to encourage women into STEM fields began to emerge, emphasizing education and professional opportunities. However, while these efforts have increased women's representation in the engineering profession, progress remains uneven across regions and disciplines. Persistent challenges, such as gender stereotypes and limited access to mentorship and leadership positions, continue to hinder the equitable participation of women in science disciplines such as engineering [33, 34].

On the other hand, a broader technical profession/discipline that is interrelated with the engineering field of study in terms of the intersectionality of gender studies is the architecture profession. Some studies have ignored the importance of women's participation in this professional field, which is thus considered significant in the discourse of women's contributions to the development of engineering disciplines/professions. The argument around this debate thus remarkably highlights the varied nature of the historical participation of women professionals across the globe in terms of contributions to architecture and engineering professions. However, women have far less freedom to shape the built environment than men do. In other words, the patriarchal social system across the globe has generally impeded women from acting as architects until recent years. Perhaps the continued resistance efforts are not surprising, as they have revealed an unexpected degree of parity in this field. However, the bridging gaps in the context of engineering professions for women showcased a shift in professionalization even in architecture across the globe, as one of the technical disciplines that women have fought to overturn existing limitations and to be equal actors in the making of place and space. Interestingly, the formalization of architecture into a profession in terms of licensing attainment has thus created both new possibilities and impediments for women to act as primary designers of the built world. This contextual issue highlights a longstanding educational barrier for women, who have continued to be pressured in terms of exclusionary mechanisms within the profession/field. Despite development in this profession in terms of creating opportunities for women, there seem to be persistent cultural barriers, thus proving surprisingly resistant to transformation. However, we argue that as research and feminism activism has become mainstream in the fields of architecture and engineering, understanding how women's rights contemporary struggles might be reconfigured to challenge the periodization and chronologies of women's practice in the architecture and engineering profession is important. This discourse can address the global contemporary geopolitics of women and the intersectionality of gender studies in terms of academic knowledge production.

Furthermore, key milestones, such as the establishment of organizations such as the Society of Women Engineers and policy interventions, which promote gender diversity and inclusivity in the engineering discipline, are arguably achievable. Despite these advances, the sticky wall phenomenon—where women leave engineering at higher rates than their male counterparts at every stage of their career—remains a critical issue of discourse. This attrition underscores the enduring cultural and systemic challenges that deter women from entering and thriving in the field of the engineering profession [35].

2.1 Theoretical perspectives from gender studies

Gender studies offer valuable theoretical frameworks for understanding the systemic challenges faced by women in the engineering discipline. Central to this analysis is the concept of gender roles, which are socially constructed expectations dictating appropriate behaviors and professions for men and women in society. These roles perpetuate stereotypes that depict the engineering discipline/profession as a masculine field, discouraging women from pursuing or persisting in these career paths [29]. The discourse of social constructionist theory as a framework underscores the core aspects of gender inequality and the reason for segregation in engineering field opportunities [51]. Many of the publications in this field largely critique the exclusion of women in the engineering profession and work development. However, there is no depth in most of the analysis to explain how women and men are socially treated differently in engineering fields and professions. Social constructionists argued for equal participation in terms of gender [17]. For example, in Africa, the social construction of women in the engineering field is viewed from a precolonial understanding of the role of women

in society [42]. This idea continues in postcolonial workplaces, where the implementation of policies is unconsciously biased toward women professionals in STEM and engineering professions. On the basis of these arguments, it is important to understand social inequality and the exclusion of women beyond the lack of participation and opportunities in the engineering field. In a way, the exclusion of women in various fields of science and engineering is socially constructed despite policies to redress it. The literature and many feminists have theorized the exclusion of women, mainly through scientific reasoning, where the human anatomy of gender is used to argue for inequality in professional fields such as engineering. However, there is a need for a more sociological lens to argue that women's exclusion in the engineering profession, for example, is historical, social, and cultural. These views are rarely used to frame the intersection of women in engineering and gender studies.

On the other hand, the social constructionism approach further shows a process of gender differences as a result of invisibility [2]. This argument considers the aspect of gender to be natural instead of social. This suggests that women should not be denied the opportunity to access and pursue their professional careers because of their physiology and anatomy. However, the argument should consider how structural and social inequalities affect women's professional development. Nevertheless, many writers believe that gender is natural and thus continues to create hindrances for professional women's success in society [24].

Intersectionality, a key notion in gender studies, highlights how overlapping identities—such as race, class, and sexuality—compound the challenges experienced by women in the engineering profession [49]. For example, women of color often encounter both racial and gender biases, creating unique challenges that require targeted interventions. This perspective underscores the need for inclusive strategies that address the diverse experiences of all women in professional engineering fields/disciplines [11]. The intersectionality framework also underscores the importance of addressing underrepresentation and promoting diversity within the engineering field/profession. This underlines that efforts toward gender equity in engineering must account for the experiences and specific needs of women from marginalized socioeconomic backgrounds. This demands inclusivity and the dismantling of barriers through diversity and inclusion initiatives. These arguments highlight the multiple facets of their identities and the interconnected systems of oppression they navigate; practitioners and researchers can gain a deeper understanding of the complexities women encounter. Furthermore, intersectionality highlights the need to consider the broader institutional, social, and cultural contexts within which women in the engineering profession navigate their careers. This includes examining structural barriers, systemic biases, and discriminatory practices that affect women differently on the basis of their intersecting identities. However, to foster equity and inclusivity in engineering, it is crucial to adopt an intersectionality lens in program development, cultural change efforts, and policymaking. Thus, incorporating intersectionality into the field of engineering can foster diversity, inclusivity, and support for success. It is important to translate the understanding of intersectionality into a concrete movement aimed at recruiting more women into the field of engineering. To achieve gender equity and promote diversity, institutions need to develop targeted strategies that address the unique challenges experienced by women from different backgrounds. Thus, by valuing and recognizing the experiences and diverse perspectives that women bring to the engineering profession, we can create an environment that attracts and retains talented women.

Feminist theories further improve the analysis by critiquing power dynamics within STEM fields. They reveal how institutional cultures and practices often marginalize women, from hiring biases to workplace environments that undervalue contributions from underrepresented groups. Applying these theories to engineering disciplines and/or professions highlights the importance of dismantling hierarchical structures and fostering collaborative, inclusive spaces that empower all members of society [44].

2.2 Importance of engineering diversity

Promoting diversity in the engineering profession/discipline is not only an issue of equity but also a driver of innovation and excellence. Diverse teams bring varied perspectives, experiences, and approaches to problem solving, which can lead to more creative and effective solutions. Studies consistently demonstrate that organizations with greater gender diversity perform better in terms of innovation, financial outcomes, and employee satisfaction [23].

However, in engineering, where solutions often address complex, real-world challenges, the inclusion of diverse voices ensures that designs and technologies are more representative of and responsive to the needs of a broader population. For example, diverse teams are more likely to consider accessibility and inclusivity in product design, benefiting society as a whole [14]. Additionally, fostering diversity in engineering is critical for addressing global challenges such as climate change, infrastructure development, and technological innovation. These issues require collaborative efforts that draw upon the talents and insights of all individuals, regardless of their gender. Society can unlock a vast reservoir

of untapped potential by creating equitable pathways for women to contribute to the engineering profession, driving progress and sustainability [26].

3 Research methodology

3.1 Approach

This study adopts a systematic literature review (SLR) to synthesize insights from existing research at the intersection of gender studies and engineering. SLR is a structured and comprehensive approach that thoroughly evaluates relevant studies, providing a solid foundation for drawing meaningful conclusions [25]. By leveraging findings from peer-reviewed articles, case studies, and interdisciplinary reports, the study captures diverse perspectives on the challenges and initiatives surrounding women in the engineering profession/discipline. This methodology aligns with the objective of providing a nuanced understanding of systemic challenges and inclusivity strategies.

The chosen SLR approach allows for the integration of knowledge from two distinct fields—engineering and gender studies—enabling the identification of patterns, gaps, and innovative interventions. However, it facilitates the consolidation of empirical data with theoretical perspectives, offering a comprehensive analysis that bridges the disciplinary gap. This method ensures that the study remains rooted in evidence while also exploring broader conceptual frameworks.

3.2 Data sources

The data for this review and analysis were drawn from a variety of academic and organizational sources to ensure depth and reliability. Academic databases such as Scopus, Springer, JSTOR, IEEE Xplore, and Elsevier provide access to peer-reviewed articles and technical studies focusing on engineering practices and diversity in the field of STEM. The articles were peer-reviewed journals from the five data sources. The search was conducted in various internationally recognized databases to collect relevant information from publications. These sources offered insights into empirical findings, historical trends, and contemporary challenges and trends faced by women in the engineering profession/discipline.

Additionally, gender study-focused databases were utilized to incorporate critical theoretical perspectives and conduct intersectional analyses. These sources enriched the review by highlighting the societal and cultural dimensions of gender inequality, which are often underexplored in the engineering literature. In addition to academic databases, organizational reports and white papers from institutions promoting diversity in STEM fields were included to capture practical initiatives and policy interventions. Documents from UNESCO, the American Society for Engineering Education, and the Women in Engineering Pro-Active Network provided valuable context for global and regional efforts to increase equity in society. These reports also offered data on the effectiveness of specific programs and strategies, contributing to a more comprehensive understanding of the landscape.

The data here include reviewed articles and reports.

The steps for the search delivery include the use of the search strings to the selected databases to collect multiple related studies. The search strings applied in the selected databases indicate the total number of studies available in terms of the search results, which are presented in Table 1 below. Thus, the number of articles included in the final analysis was influenced by the search criteria we used as linked to the planned research aims to be achieved. Therefore, the sizes and types of databases used for searching for related publications determine the sample sizes used for the analysis. Before conducting the systematic literature review search, we conducted a pilot literature search to refine our search keywords to cover the targeted study purposes related to understanding women's underrepresentation in the engineering profession as linked to gender studies and intersections.

3.3 Selection criteria

To maintain the relevance and rigor of the review, specific criteria were applied in selecting studies. Only research published within the last 5 years was included, ensuring that the findings reflect current challenges and advancements. However, this time frame also captures the impact of recent initiatives and policy changes aimed at increasing diversity in engineering.

Studies that addressed intersectional perspectives were prioritized, recognizing that the experiences of women in the engineering profession/discipline are not homogeneous. Studies that explored systemic challenges, such as

Table 1 The search terms used and the total number of publications in each database

Databases	Searching string and searching terms		No. of articles
Scopus	Main search terms using doc "Women and engineering" And "Gender Studies"		60
	Title, abstract, and keywords		
	Secondary search terms	"Women in Engineering Studies"	56
		"Women in Engineering" and "Intersection"	35
		"Women in Engineering" and "Equity"	25
		"Women in Engineering" and "Inclusion"	10
"Women in Engineering" and "Diversity"			20
		"Women in Engineering" and "Gaps"	40
		"Women in Engineering" and "Challenges"	28
Springer	Main search terms	"Women and engineering" and "Gender Studies"	72
	Secondary search terms	"Women in Engineering Studies"	105
		"Women in Engineering" and "Intersection"	95
		"Women in Engineering" and "Equity"	114
		"Women in Engineering" and "Inclusion"	52
		"Women in Engineering" and "Diversity"	34
		"Women in Engineering" and "Gaps"	45
		"Women in Engineering" and "Challenges"	30
JSTOR	Main search terms	"Women and engineering" and "Gender Studies"	4
	Secondary search terms	"Women in Engineering Studies"	12
		"Women in Engineering" and "Intersection"	9
		"Women in Engineering" and "Equity"	18
		"Women in Engineering" and "Inclusion"	13
		"Women in Engineering" and "Diversity"	7
		"Women in Engineering" and "Gaps"	26
		"Women in Engineering" and "Challenges"	20
IEEE Xplore	Main search terms	"Women and engineering" and "Gender Studies"	6
	Secondary search terms	"Women in Engineering Studies"	15
		"Women in Engineering" and "Intersection"	7
		"Women in Engineering" and "Equity"	12
		"Women in Engineering" and "Inclusion"	5
		"Women in Engineering" and "Diversity"	3
		"Women in Engineering" and "Gaps"	18
		"Women in Engineering" and "Challenges"	21
Elsevier	Main search terms	"Women and engineering" and "Gender Studies"	17
	Secondary search terms	"Women in Engineering Studies"	2
		"Women in Engineering" and "Intersection"	1
		"Women in Engineering" and "Equity"	6
		"Women in Engineering" and "Inclusion"	2
		"Women in Engineering" and "Diversity"	16
		"Women in Engineering" and "Gaps"	4
		"Women in Engineering" and "Challenges"	8

institutional biases and cultural norms, were also given precedence. This focus ensured that the review captured the individual and structural dimensions of the issue.

The inclusion criteria further emphasized the importance of multidisciplinary approaches. Studies that combined insights from gender studies and engineering practices were particularly valuable, as they offered holistic perspectives on challenges and potential solutions. By adhering to these criteria, the review maintained its alignment with the paper's objectives while ensuring methodological rigor.

3.4 Data analysis framework

Thematic analysis was employed in this study, allowing for the identification of recurring themes, trends, and gaps. This method involves coding and categorizing the process of data on key relevant topics, enabling a systematic exploration of the findings. The analysis focused on three main categories: challenges, interventions, and outcomes.

Challenges, such as implicit biases, gendered stereotypes, and exclusionary workplace cultures, were analyzed to uncover systemic issues that hinder women's participation in the engineering profession. Interventions were categorized to highlight successful initiatives, including mentorship programs, policy reforms, and educational strategies. The outcomes were evaluated to assess the effectiveness of these interventions in promoting equity and inclusivity in society. A multidisciplinary lens was applied throughout the analysis, integrating insights from the perspective of gender studies and engineering practices. This approach facilitated a deeper understanding of the interplay between cultural and technical factors, ensuring that the findings are both comprehensive and reliable. The methodology approach adopted in this study is unique and differs from other conventional methodologies. Thus, this particular approach was used to select data systematically from different scholarly databases explicitly and answer the research question identified in this research. These systematic criteria contrast with predefined narrative reviews because relevant studies linked to the topic were sourced, synthesized, and analyzed via a quality assessment without biases.

4 Results and discussion

The findings of the study revealed that a large proportion of the articles'titles and abstracts, including the contents of the full texts and reports retrieved from different databases related to women in engineering professions as linked to gender studies and intersectionality, were systematically reviewed. Studies published before 2020 were discarded and excluded from the literature search because they were not related to engineering fields/disciplines. The reasons for this exclusion are that this study specifically focused on women in the engineering field on the basis of the current development of women's involvement to highlight the significant impact and relevance of women's inclusion and how these disciplines intersect with their profession, using the gender lens to address the issues that have arisen in this context. The results of the systematic review in this study are not farfetched from the fact that evidence has revealed a gap for advancement in the engineering profession for women despite government, institutional, and organizational efforts to unravel the menace of gender inequality in the engineering profession. Therefore, the literature has to some extent addressed the issues of the systemic and structural patterns of gender dynamics in society in terms of gender parity in technical fields such as engineering for professional women engineers.

The systematic literature review of the intersection of women in engineering and gender studies reveals critical insights into the challenges they face and, thus, how gender roles are reshaped within the professional engineering field. Through systematic reviews, the study revealed the inherent patterns of intersectionality as linked to inequality for women and gender identities in the engineering profession, with a particular focus on the issues they experienced and the evolving landscape of the engineering profession. However, this study further revealed that women in the engineering profession experience a range of interrelated challenges that stem from cultural, educational, workplace, and intersectional dynamics. These challenges often begin early in life and persist throughout education and professional careers, creating systemic obstacles that hinder their representation and career advancement [6]. Understanding these challenges is critical for addressing the gender gap in the engineering profession and fostering a more inclusive environment for more women's participation.

Thus, one of the key findings that was crucial in this study is that cultural and societal norms significantly shape career aspirations and choices, often steering women away from the engineering profession. Gender stereotypes, which are deeply entrenched in many societies, depict technical fields as the domain of men while portraying women as more suited to caregiving or creative professions [18]. These stereotypes are reinforced through media, education, and familial expectations, creating a perception that the engineering profession is not for women. Societal expectations also influence young girls'choices regarding their education and careers. Parents, teachers, and peers may unintentionally discourage girls from pursuing technical subjects by questioning their aptitude or steering them toward fields considered more feminine, such as nursing. These subtle forms of biases have long-term consequences, narrowing the paths through which women enter engineering disciplines and perpetuating their underrepresentation [45]. This finding, as revealed in this study, reinforces the argument that women are culturally confined to some spaces in terms of pursuing a career

in a profession that is believed to be occupied by males in society. This argument may be true on the basis of evidence that women concentrate on professions considered feminine and struggle to break through the glass ceiling and achieve success in terms of advancement in professions/disciplines that have historically been dominated by the *male* gender, such as the technical and engineering professions.

Aside from the cultural and societal issues that this study revealed intersecting with women's professional careers in engineering professions, women's educational experiences in engineering often reflect systemic biases that deter them from pursuing or persisting in the engineering discipline. In schools and universities, girls frequently encounter implicit biases from teachers and peers, who may underestimate their abilities or fail to encourage their interest in technical subjects [38]. This lack of encouragement has been found to lead to lower self-confidence, even among high-achieving students, discouraging them from pursuing advanced studies in the engineering discipline. A critical challenge in education is the scarcity of female role models in engineering disciplines. The absence of visible and relatable examples of successful women in the field reinforces the notion that engineering is male dominated. This lack of representation can contribute to feelings of isolation and imposter syndrome among female students, further diminishing their likelihood of pursuing engineering careers [3]. Gender biases in academic environments also create additional challenges. Women often face skepticism about their abilities, receive less support from mentors, and are excluded from networking opportunities that are vital for career development. These challenges are compounded by curricular materials and teaching methods that may fail to address gender equity, inadvertently reinforcing existing disparities [63]. The problems identified in these findings concur with the argument that revealed the unavailability of enough support mechanisms for women to pursue educational careers in engineering professions/fields. However, gender studies are considered not to have gained enough high momentum in schools and universities to understand some of the inherent problems related to gender issue studies in society. This compounded issue related to the academic environment has created segregation for women and girls from engineering disciplines and professions, which is an indication that the school and higher education institution settings are gendered in terms of not creating more opportunities for women to choose and pursue careers in the field of engineering disciplines.

This study revealed that the workplace is gendered to women professional engineers. This revealed the challenges for women who enter the engineering workforce, thus extending to organizational cultures and practices. Implicit biases are pervasive in hiring, promotion, and evaluation processes, often leading to unequal opportunities for advancement for women. Women are frequently overlooked for leadership roles or high-visibility projects, contributing to inequality, which limits their professional development [28]. Workplace discrimination is another significant barrier, ranging from microaggressions to more overt forms of discrimination. Such experiences create a hostile work environment, leading to job dissatisfaction, burnout, and higher attrition rates among women professional engineers. The lack of robust reporting mechanisms and organizational accountability often exacerbates these issues, leaving many women without recourse [56]. Unequal pay has been identified and found to be a persistent problem, with women in the engineering profession earning less than their male counterparts for similar roles and responsibilities. This disparity not only reflects gender inequities but also undermines women's financial independence and career satisfaction. Combined with limited access to flexible work arrangements and support for work—life balance, these factors contribute to the "leaky pipeline" phenomenon, where women leave the profession at higher rates than men do [31]. The findings reflect the traditional workplace structure and culture of undermining women's professional contributions to engineering fields. This explains the inequality syndrome evident in workplace policies that are unfavorable to women professionals in the field of the engineering profession and thus do not encourage them, which might affect their career development.

On the other hand, intersectional identity is linked to the experiences of women in engineering professions; thus, ununiform, intersectional identities significantly influence women's experience. Women from underrepresented racial or ethnic groups have been found to often encounter compound challenges, including racial biases and exclusion from predominantly male professional networks. For example, women of color may experience stereotypes that call into question both their technical competence and their "fit" within engineering cultures, leading to greater isolation and fewer opportunities for career advancement [9]. In this study, other gender identities, such as LGBTQ + individuals in the engineering profession, were found to experience unique challenges, including discrimination based on sexual orientation or gender identity. These individuals often contend with a lack of inclusive workplace policies and cultural norms that fail to recognize or respect diverse identities. Such exclusionary practices further marginalize already underrepresented groups, limiting their ability to thrive in engineering environments [12]. Aside from other gender identities, women with disabilities, those from low-income backgrounds, and other marginalized groups have been found to encounter additional challenges, including limited access to educational resources and other opportunities in the engineering field. These intersectional challenges underscore the importance of

adopting inclusive strategies that address all women's diverse experiences and needs in engineering disciplines/professions [40]. In other words, the challenges experienced by women in engineering disciplines/professions are complex and multifaceted and involve cultural, educational, workplace, and intersectional dynamics. Addressing these challenges requires a comprehensive, intersectional approach that identifies systemic issues and implements targeted interventions. The arguments in these findings underscore the isolation of different gender identities in the engineering field in terms of intersectionality. These contentious issues have been increasingly problematic for women in the professional space of the technical field to achieve success in terms of career advancement. However, these research findings highlight the uniqueness of the systematically reviewed literature, which is broad to the context of the focus of the study. However, deep critical issues related to inherent persistent gaps in gender studies, such as being linked to women in the engineering profession and intersectionality, were identified. This study differs from other studies in this discourse field of women and engineering, as it indicates that women are socially constructed by societal cultural patterns, thus determining the gender dynamics of women in professional technical fields such as engineering, which women engineers still struggle to advance in their career paths and adequately represent in leadership roles.

Despite significant progress in understanding the challenges experienced by women in the engineering profession, gaps in the advancement and interpretability of marginalized identities that thus intersect with women engineers'career trajectories have been identified. Thus, this aspect may not have been adequately researched as to how race and socioeconomic status interact with gender to shape career outcomes. Research has shown that the global workforce has a critical underrepresentation of women in the engineering profession; thus, these gaps were found to be more pronounced in leadership roles, where women hold very few of the top in all engineering professional fields [55]. These identified systemic gender gaps in the engineering field for early-career and professional women engineers are evidence of policy inconsistency, and several studies have yet to address these inherent contextual systemic issues related to societal biases, cultural perceptions, workplace practices, educational inequalities, and gender unfairness, which are still persistent in the engineering field/profession.

This study contributes to policy reforms to drive systemic transformation. This restructuring of policies will support the government, organizations, and institutions'policy agenda to enforce policies mandating gender-neutral practices, equal pay, and antidiscrimination regulation in professional engineering fields/disciplineries. This will significantly improve quotas for women's representation and gender balance in the engineering field in terms of research projects and leadership roles.

5 Gender-inclusive education and engineering practices

5.1 Curricular reforms

Integrating gender-sensitive content into curricula is one of the most impactful ways to foster inclusivity in engineering education. Traditional engineering programs often emphasize technical rigor while overlooking the societal and ethical dimensions of the discipline. Incorporating discussions on gender equity, implicit biases, and intersectionality within engineering courses can help students recognize the broader social implications of their work [57].

Such reforms also involve revising teaching materials to ensure that they reflect diverse perspectives and contributions. Highlighting the achievements of women engineers and other underrepresented groups can inspire students and challenge stereotypes about who can succeed in technical fields. Case studies and problem-solving exercises that address real-world issues, such as designing for underserved populations, can further emphasize the importance of diversity in engineering.

Additionally, interdisciplinary courses that combine engineering with social sciences, such as gender studies, can equip students with tools to understand and address systemic inequalities. These programs encourage future engineers to approach their work with empathy and a deeper awareness of societal dynamics, ultimately leading to more inclusive innovations in this field [61].

5.2 Teaching and mentorship

Creating supportive academic environments is essential for fostering the success of women in engineering. Educators play a critical role in shaping students'perceptions and experiences, making it imperative to adopt inclusive teaching practices. Strategies such as active learning, collaborative projects, and personalized feedback can help all students feel valued and engaged, particularly those from underrepresented groups.

Mentorship is another vital component of gender-inclusive education. Faculty members and senior students who serve as mentors can provide guidance, encouragement, and networking opportunities for women in engineering. Peer mentorship programs, where experienced students support their junior counterparts, can foster community and belonging [48].

Training faculty to recognize and address implicit biases is essential to creating equitable learning environments. Professors and teaching assistants must be aware of how their interactions, expectations, and grading practices can inadvertently disadvantage women and other marginalized groups. Workshops and professional development programs on inclusive pedagogy can equip educators with the skills to support diverse student populations effectively [30].

5.3 Engineering design with gender in mind

Inclusive engineering practices extend beyond education to the professional realm, where the principles of equity can inform the design and implementation of technologies. Engineers have a unique opportunity to address social inequalities by considering the diverse needs of users during the design process [19]. For instance, gender-sensitive design can address disparities in public infrastructure, healthcare, and consumer products. Urban planning that prioritizes the safety and accessibility of public spaces for women, medical devices tailored to physiological differences, and inclusive technology interfaces are examples of how engineering can contribute to social equity [5].

Diverse teams are particularly well suited to developing inclusive designs, as they bring various perspectives and experiences to the table. Organizations that prioritize gender diversity in their engineering teams are more likely to produce innovative solutions that meet the needs of a broader population. Engineering education can play a crucial role in preparing students for this approach by incorporating design thinking exercises that emphasize inclusivity. Courses on human-centered design, sustainability, and ethics can teach students to consider the social impact of their work and prioritize equity in their projects [62].

The integration of gender-inclusive practices in education and professional engineering has implications that extend far beyond the discipline itself. Addressing inequalities and fostering diversity contribute to a more just and equitable society. Inclusive engineering practices can also enhance innovation, as diverse teams are more likely to identify creative solutions effectively and address complex challenges [43]. Furthermore, gender-sensitive education and practices can inspire future generations to pursue engineering careers. When young girls see themselves represented in curricula, teaching staff, and professional teams, they are more likely to view engineering as a viable and rewarding career path. This increased representation can help break the cycle of underrepresentation and create more diverse pathways of talent for the profession [60].

5.4 The role of intersectionality and diverse experiences

Women in engineering face a spectrum of challenges shaped by their intersecting identities. For instance, women of color often navigate dual layers of bias—gender and racial. Studies have shown that they experience higher rates of microaggressions, exclusion from professional networks, and underrepresentation in leadership roles than their white counterparts do [36]. These compounded challenges not only affect their career progression but also contribute to a heightened sense of isolation in predominantly male and racially homogeneous environments [26].

Socioeconomic status is another significant factor. Women from low-income backgrounds often encounter systemic obstacles long before they enter the engineering workforce. Limited access to high-quality STEM education, fewer opportunities for advanced training, and financial constraints can hinder their ability to pursue engineering degrees. Even when they enter the field, these individuals may lack the social capital needed to navigate professional networks effectively [42].

However, individuals with other gender identities often encounter workplace cultures that are not inclusive, leading to a higher incidence of discrimination and a reluctance to disclose their identities. Such environments can exacerbate stress and reduce job satisfaction, ultimately affecting retention rates for this group [41].

Disability adds another layer to the intersectional experiences of women in engineering. Physical and cognitive impairments often necessitate workplace accommodations, yet many organizations lack adequate resources or policies to support employees with disabilities. The absence of accessible facilities, coupled with stigma, can further marginalize these women, making it difficult for them to thrive professionally [15].

6 Implications for policy interventions and interdisciplinary

Governments, academic institutions, and organizations have implemented various policies to improve gender representation in the engineering field. Gender quotas are interventions designed to ensure a minimum percentage of women in educational programs, leadership roles, and professional teams. While quotas can drive initial increases in representation, their long-term effectiveness depends on complementary measures, such as addressing cultural biases and workplace dynamics that affect women's careers [64].

Diversity mandates have become increasingly common, requiring organizations to report on gender representation and commit to measurable goals. These mandates encourage accountability and transparency, pressurering institutions to adopt inclusive hiring and promotion practices. For example, initiatives promoting blind recruitment—where personal details are anonymized—have been shown to reduce biases during the selection process [58].

Mentorship programs are another key intervention, offering women engineering guidance and support from experienced professionals. These programs aim to build confidence, enhance skills, and expand networks for women, helping them navigate the challenges of male-dominated fields. Some mentorship models also include sponsorship components, where mentors actively advocate for their mentees' advancement within the organization [21].

Several organizations and institutions have demonstrated the potential for transformative change through well-designed interventions. One notable example is the Athena SWAN Charter, a UK-based initiative that recognizes and rewards universities and research institutions for advancing gender equity. However, when gender considerations are integrated into institutional policies, Athena SWAN has helped increase the number of women in engineering faculties and leadership positions [65].

Similarly, large corporations such as Google and General Electric have launched diverse programs tailored to engineering roles. These initiatives often include mentorship opportunities, leadership training for women, and targeted recruitment campaigns to attract female talent. In Google, for example, the "Made with Code" program aims to inspire young girls to pursue careers in engineering and technology by showcasing the creative and impactful applications of coding [47].

Academic institutions such as Harvey Mudd College in the United States have also successfully increased female representation. Thus, by redesigning engineering curricula to emphasize collaboration and real-world applications, colleges have significantly increased the proportion of women graduating from their programs. These success stories underscore the importance of proactive measures and sustained commitment to fostering inclusivity in the workplace and institutions [1].

6.1 Evaluation of effectiveness

Significant limitations and gaps remain despite the progress achieved through existing policies and programs. While effective in addressing numerical disparities, gender quotas often face resistance from stakeholders, who perceive them as undermining meritocracy. This perception highlights the need for broader cultural change to ensure that quotas are seen as tools for equity rather than tokenism [10].

Diversity mandates and mentorship programs also face challenges in their implementation. Reporting requirements under diverse mandates can sometimes lead to superficial compliance rather than meaningful change. Similarly, mentorship programs may fail to address structural challenges if they focus solely on individual support without challenging organizational norms [7].

Intersectional considerations are another area where current approaches often fall short. Many interventions primarily target gender disparities without accounting for the compounded challenges faced by women from underrepresented

groups. Addressing these gaps requires a more nuanced understanding of the diverse experiences of women in engineering and tailored strategies to meet their needs [59].

Several strategies have emerged as particularly effective in fostering inclusivity and addressing systemic challenges. One key lesson is the importance of integrating diversity and inclusion into organizational culture rather than treating them as isolated initiatives. Leadership commitment to equity and regular training on implicit biases and cultural competence can create an environment where all employees feel valued and supported [54].

Another critical insight is the value of early intervention. However, programs that engage girls in STEM education from a young age and provide them with role models can help counteract stereotypes and build confidence. Organizations that collaborate with schools, institutions, and community groups to promote engineering as an accessible and rewarding career option are better positioned to expand the career pathways of female talent [50].

Therefore, collaboration between stakeholders is also essential. Partnerships between academia, industry, and government can pool resources and expertise to design comprehensive interventions. For example, initiatives that combine scholarship funding with workplace mentorship opportunities and policy advocacy can achieve a more significant and sustainable impact [27]. However, continuous evaluation and adaptation are crucial to the success of any policy or practice. Organizations must regularly assess the outcomes of their diverse efforts, identify improvement areas, and incorporate stakeholder feedback. Transparent reporting on progress and challenges can build trust and accountability, ensuring that diversity remains a priority in our society.

6.2 Interdisciplinary opportunities

Collaboration between gender studies and engineering offers immense potential to drive innovation and equity. Gender studies, with their focus on systemic analysis and social constructs, provide valuable frameworks for understanding and addressing the root causes of inequality in engineering.

Conversely, engineering's problem-solving ethos can contribute practical solutions to complex societal challenges.

One opportunity for interdisciplinary collaboration lies in research and development. Engineers and gender studies scholars can work together to design technologies that promote inclusivity and social justice. For example, wearable technologies tailored to women's physiological needs or urban planning projects that prioritize safety for diverse populations illustrate how this partnership can create impactful innovations.

Another area of collaboration is education. However, joint courses that combine technical training with social analysis can equip engineering students with the skills to approach their work through an equity lens. Interdisciplinary and multidisciplinary research centers focus on diversity in STEM, which can also serve as hubs for generating new knowledge and fostering dialog between the two fields. Furthermore, interdisciplinary and multidisciplinary approaches can inform policy development. Thus, by integrating insights from gender studies into engineering policy frameworks, stakeholders can create more comprehensive strategies for addressing systemic challenges. For example, policies designed to increase representation in engineering could draw on gender studies to account for the intersecting identities and experiences of diverse groups.

7 Recommendations

These findings suggest a policy transformation for governments, organizations, and institutions to reformulate policy initiatives to address the persistent contextual issues of unequal representation and participation for women who intend to build a career in the engineering profession and field. To drive this systemic change, it is recommended that the government redress the gender policies of society, particularly in the gazette of the employment policies of equity in the workforce, to encourage every gender irrespective of their identities. However, government genuine policy agendas on gender mainstreaming equality ultimately will turn around the situational context of inequalities in the technical profession, such as the engineering field, which has historically been dominated by men. This approach may change the societal and cultural beliefs of women being confined to a certain profession. As a result, these initiatives will serve as a rethink for society to support and encourage women of different socioeconomic backgrounds to excel in their career trajectories, as many women are talented and can contribute to sustainable societal development. The government will not only achieve gender parity success in this context but also create an unbiased society that is free of discrimination or segregation against women professionals to successfully achieve their desired ambitions, particularly in engineering professions/disciplines.

However, one of the key recommendations of this study is for organization and workplace policies and practices to accommodate a gender-friendly work environment that will be inclusive and diverse to address persistent systemic barriers that hinder the career advancement of women in the engineering profession. Therefore, it is suggested that organizations adopt a strong policy implementation approach to prevent anti-discrimination against female engineers and promote diverse training policies for employees irrespective of their gender identity. Thus, organizations should incorporate in their employment conditions of work for women to have flexible work arrangements, such as remote work options for parental leave, to accommodate the diverse needs of women engineers, particularly those balancing professional and caregiving responsibilities. The recruitment and retention policies of organizations are suggested to prioritize inclusivity for all genders by reexamining traditional hiring practices. However, organizations should implement a blind recruitment process policy for women engineers, which eliminates identifying information that prevents implicit biases in the selection process. Additionally, organizations should partner with universities and professional associations to create talent pathways that specifically target women engineers and other underrepresented groups. To ensure accountability, organizations and institutions must establish metrics for tracking progress in diversity and inclusion efforts. Regular reporting on gender representation in terms of pay equity and the workplace environment can help identify areas for improvement and reinforce a commitment to systemic change.

This study recommends institutional practice to expand and revise the implications within engineering education, particularly in fostering an institutional environment that supports and retains women in the engineering discipline/field. An insight into this is the recognition that effective institutional mentorship is not confined by gender boundaries. However, it is suggested that academic mentors in the field of engineering can drive significant inspiration for girls and women in terms of supporting them in achieving the desired success in their career paths. Therefore, engineering programs in institutions should be encouraged to cultivate gender-inclusive mentorship opportunities. Additionally, this study suggested active institutional participation from male faculty and industry professionals, ensuring that they are equipped through training to address the unique challenges faced by women in engineering effectively. However, schools and educational programs should be encouraged to prioritize hands-on, inquiry-based learning experiences that ignite interest in engineering from a young age, effectively dismantling gender stereotypes associated with the engineering discipline/field. This approach will lead to the development of partnerships with local schools in terms of hosting workshops aimed at engaging young girls in engineering, featuring women role models, institutions can lay a foundational interest and counter prevailing stereotypes.

8 Conclusion

This paper explores the multifaceted challenges and opportunities at the intersection of women in the engineering profession and gender studies. It has underscored systemic challenges, including cultural stereotypes, educational gaps, and workplace biases, that perpetuate gender inequalities in the field. Moreover, the examination of intersectional identities has highlighted how compounded challenges disproportionately impact women from underrepresented groups, amplifying the need for nuanced approaches to inclusion. The analysis also revealed the value of diversity in the engineering profession/field, emphasizing how inclusive teams foster innovation, creativity, and improved decision-making. Policies implications for practices and interventions such as mentorship programs, diversity quotas, and workplace flexibility were evaluated for their effectiveness in fostering equity. The integration of gender-sensitive education and inclusive engineering practices was highlighted as a critical step toward reshaping the cultural and institutional frameworks that define the field.

Addressing gender inequalities in engineering is not merely a moral imperative but also a strategic necessity for fostering innovation and driving societal progress. Stakeholders across academia, industry, and policy implementers must commit to sustained, collaborative efforts to dismantle the systemic challenges that women experience. Educational institutions should lead by integrating gender-sensitive curricula and fostering supportive environments where women can thrive. Organizations must adopt robust diversity and inclusion strategies, setting measurable goals to increase representation and ensure equitable treatment. Policymakers should develop and enforce frameworks that hold organizations accountable for creating inclusive spaces.

Therefore, mentors, educators, and leaders play crucial roles in inspiring and empowering the next generation of women engineers. Advocacy organizations and professional networks must continue to amplify voices, provide resources, and drive awareness campaigns to challenge stereotypes and biases. This collective responsibility extends globally, recognizing that cultural and socioeconomic contexts vary widely. Globally, organizations, governments, and institutions

must work together to develop solutions that account for local realities while adhering to universal principles of equity and social justice for women engineers in society. While our research offers insights into the intersection of women in engineering and gender studies, it is essential to acknowledge the limitations of the research related to its scope and methodology. Understanding these limitations is crucial for contextualizing the research findings and guiding future research. The focus on the intersection of women in the engineering profession/field limits the generalizability of the findings. The uniqueness of the intersectionality of women engineers and gender studies, particularly their interdisciplinary specific context, may not represent the experiences of women in other STEM professions/disciplines. However, the persistent underrepresentation of women in the engineering profession/disciplines necessitates ongoing exploration to address systemic inequalities. Future research must prioritize implementing targeted policy recommendations and fostering interdisciplinary and multidisciplinary collaboration between gender studies and engineering. This will create strategic directions, emphasizing the need for comprehensive, data-driven approaches to create lasting transformation in the engineering profession/field.

Author contributions A.G. contextualized the introduction aspect of the study. D.R.E. analyzed the historical and contextual trends of women professionals in the engineering profession. A.G. discussed the theoretical lens used in the analysis of the study from a gender studies perspective. D.R.E. explained the importance of engineering profession diversity in society. A.G. conceptualized the methodological approach adopted in this systematic literature review (SLR) to synthesize the intersection of gender studies and engineering. A.G. discussed the section of the study results and discussion that argues for the challenges faced by women in the engineering profession, the gaps identified and novel contributions to knowledge in the field of engineering profession as connected to intersectionality of gender studies. D.R.E. clarified the aspects of policy implications and interventions to improve gender representation in engineering. A.G. critically discussed the section on gender-inclusive education and engineering practices. D.R.E. explained the subsection of engineering design with gender in mind in terms of inclusive engineering practice. A.G. This section discusses the role of intersectionality in arguing for diverse experiences, policies, and organizational insights. D.R.E. Discussed strategic directions, and interdisciplinary opportunities as suggested in the study section. D.R.E. and A.G. recommend that gender inequalities in engineering are not merely a moral imperative but also a strategic necessity for fostering innovation and driving societal progress, conclusions limitation and future research strategy were discussed, and summarize that policies should prioritize diversity by reexamining traditional hiring practices.

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Declarations

Ethics approval and consent to participate Ethics approval review or approval by an ethics committee was not required for this study, as it is a review study.

Competing interests The authors declare that they have no competing interests.

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