Who invented that? A man, most likely

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Abstract

The persistent underrepresentation of women in STEM fields, especially in patent-heavy disciplines like engineering, biotechnology, and computer science, poses significant challenges to innovation and societal progress. Despite some advancements in gender parity, systemic barriers, cultural biases, and structural inequities continue to hinder women's full participation in these critical areas. Women make up only 13% of U.S. patent inventors and 35% of STEM scientists, reflecting ongoing disparities that stem from both educational and professional environments. Intellectual property systems, often prioritizing traditionally masculine modes of invention, further exacerbate these gaps. This literature review investigates the gender disparities within intellectual property (IP) fields and examines how engineering education can address these issues. Through a narrative literature review of recent studies, the paper highlights the necessity of transformative changes in STEM education and IP frameworks to create a more inclusive innovation ecosystem. The research underscores the importance of diversity in innovation, noting that diverse teams generate more creative solutions, particularly in areas such as healthcare and caregiving technologies where women tend to focus. Furthermore, the study explores how engineering education influences career trajectories and the role of early exposure to engineering concepts in fostering innovation. Integrating intellectual property education within engineering curricula is proposed as a means to empower women, linking technical skills with practical career applications. Addressing structural barriers within engineering education, including gender stereotypes and lack of mentorship, is essential to increasing women's participation. Institutional challenges within patent systems, including implicit biases and the undervaluation of women-led inventions, are also examined. Women's innovations, particularly those targeting societal needs, often receive less institutional and financial support, perpetuating a cycle of underrepresentation and undervaluation. The paper calls for targeted interventions in both educational and professional environments to ensure equitable representation and foster a more diverse and innovative landscape. By enhancing support structures and revising patent examination policies, the innovation ecosystem can better harness the potential of diverse perspectives, leading to broader societal advancements.

I. Introduction

The persistent underrepresentation of women in STEM fields, particularly in patent-heavy disciplines like engineering, biotechnology, and computer science, has far-reaching implications for innovation and societal progress. Despite some strides in gender parity, systemic barriers and cultural biases continue to limit women's participation in these critical domains. Recent data indicates that women account for only 13% of U.S. patent inventors and 35% of STEM scientists, showing significant gender disparities in innovation (Koning et al., 2021; Stoet & Geary, 2018). These gaps are compounded by structural inequities in education and professional

environments, as well as gender-biased norms within intellectual property systems, which prioritize traditionally masculine modes of invention (Lai, 2020; Revankar, 2022). Engineering education plays a crucial role in shaping the innovation pipeline. Existing literature reveals how understanding how patents work should be an integral part of engineering education (Garris & Garris, 2017; Kaplan & Kaplan, 2003). Moreover, women's inventions, which frequently address unmet societal needs such as women's health and caregiving technologies, are systematically undervalued, resulting in missed opportunities for societal advancement (Koning et al., 2021). This paper explores the gender disparities in intellectual property (IP) fields and the role of engineering education in bridging these gaps. By performing a narrative literature review from recent literature, this paper highlights the need for transformative changes in STEM education and intellectual property frameworks to foster an inclusive innovation ecosystem.

II. Background and Literature Review

A. Importance of Diversity in Innovation

Diversity in innovation is not just a matter of equity; it is essential for technological advancement and societal progress. Studies consistently show that diverse teams bring a broader range of perspectives, fostering creativity and producing solutions that address the needs of a wider population (Koning et al., 2021; Lai, 2020). Women, for instance, are more likely to focus on addressing societal needs, particularly in areas such as healthcare and caregiving technologies, which men may overlook (Koning et al., 2021). However, systemic barriers, such as the lack of women receiving patents over their male-counterparts, continue to limit women's participation in innovation, depriving society of their unique contributions and hindering the development of more inclusive solutions (Revankar, 2022; Wang et al., 2020).

B. Overview of Patent-Heavy Industries

Patent-heavy industries, such as mechanical engineering, computer science, and biotechnology, play a pivotal role in driving global technological and economic progress. These sectors thrive on cutting-edge research and development, producing innovations that shape modern life, from medical breakthroughs to technological infrastructure (Garris & Garris, 2017). Mechanical engineering focuses on designing and optimizing machinery and systems, often foundational to advancements in transportation, energy, and manufacturing. Biotechnology has been instrumental in revolutionizing medicine and agriculture, with patents serving as critical tools for protecting and commercializing inventions. (Linton *et al.*, 2008). Similarly, computer science underpins rapid advancements in artificial intelligence, cybersecurity, and data processing, domains with profound societal impacts (Khaleel, 2024). Despite their potential for transformative innovation, these industries have been criticized for perpetuating gender disparities, with limited efforts to create inclusive environments for women (Koning et al., 2021).

C. Current State of Female Representation in STEM and Patents

Despite gradual progress, women remain significantly underrepresented in STEM fields and within patent-heavy industries. Women account for approximately 13% of inventors on U.S. patents, and 77% of all patents lack any female inventors. If the current rate of change persists, gender parity in patenting would not be achieved until 2092 (Subramani & Saksena, 2024). Additionally, even in collaborative settings, women tend to be credited less frequently than their male counterparts, a disparity that extends to patent citations and commercialization outcomes (Schuster et al., 2022). Women's underrepresentation is particularly pronounced in engineering and physical sciences, fields critical to patent-heavy industries. For instance, women earn only 20% of engineering degrees despite constituting a majority of college graduates. This gap is compounded by systemic challenges such as limited mentorship opportunities, implicit biases in the workplace, and inequitable resource distribution (Stoet & Geary, 2018; Vishnubhakat, 2014). Furthermore, women face higher attrition rates during the patent examination process, and their patents are less likely to be cited in follow-up research, which diminishes their visibility and perceived impact (Porter, 2019; Subramani & Saksena, 2024). Data from the U.S. Patent and Trademark Office highlight that while patents by female inventors have increased since the 1980s, progress has been uneven. By 2020, 21.9% of patents included at least one female inventor, compared to only 3.4% in 1977. However, this growth has not matched the rate of women's entry into STEM fields, underscoring structural barriers within the patenting system (USPTO, 2020). The academic sector reflects similar trends. Women in academia patent at only 40% of the rate of their male counterparts, even in fields where gender parity is approaching, such as the life sciences. This discrepancy is often attributed to limited access to institutional support, networks, and commercialization resources (Schuster et al., 2022). Research suggests that women's patents are more likely to focus on societal needs, particularly in healthcare and caregiving technologies. However, these innovations often receive less institutional and financial backing, perpetuating a cycle of underrepresentation and undervaluation (Koning et al., 2021; Lai, 2020). Addressing these disparities requires targeted interventions in both STEM education and the broader patent ecosystem. Enhancing support structures, promoting inclusive education, and revising patent examination policies are essential steps to ensure equitable representation and foster a more diverse and innovative landscape.

III. Systemic Barriers to Female Representation

A. Structural Barriers in Engineering Education

Women continue to face significant obstacles in entering STEM and engineering education. Despite being the majority of college graduates, women represent only about 20% of engineering degree recipients (Stoet & Geary, 2018). This disparity stems from entrenched societal norms and limited early exposure to engineering fields in primary and secondary education, where girls are often dissuaded from pursuing technical subjects (Subramani & Saksena, 2024). Moreover, research highlights the "gender-equality paradox," where women in gender-equal countries are

less likely to enroll in STEM fields compared to those in less gender-equal nations, due in part to broader career choices and societal pressures that steer them away from technical disciplines (Stoet & Geary, 2018). This paradox underscores the nuanced ways in which economic and social contexts shape educational and career decisions. Another obstacle is the cultural stereotypes that perpetuate the idea that STEM fields are better suited for men. This continues to limit women's participation in these disciplines. From a young age, girls are often socialized to view engineering and technology as masculine domains, which discourages them from pursuing these fields and affects their confidence in STEM-related abilities (Koning et al., 2021). The lack of an inclusive learning environment further exacerbates this issue, as women frequently encounter implicit biases and microaggressions in classrooms and labs that diminish their sense of belonging and ability to thrive (Schuster et al., 2022). These biases are often reinforced through educational materials and cultural messaging that fail to portray women as successful engineers or scientists. The absence of mentorship and role models for women in engineering is another critical barrier to their success. Research shows that access to mentors significantly enhances retention and career progression in technical fields, yet women often lack such support systems (Porter, 2020). The scarcity of female faculty and professionals in engineering compounds the issue, making it difficult for aspiring female engineers to find relatable guidance or networks. Moreover, without visible women in leadership positions, systemic biases within institutions remain unchallenged, further perpetuating gender disparities in engineering education and career advancement (Vishnubhakat, 2014).

B. Institutional and Systemic Challenges in Patent Systems

Patent systems have historically mirrored broader societal biases, disadvantaged women inventors. Women are less likely to file patents and, when they do, face lower success rates in patent approval processes (Schuster et al., 2022). Inventions in domains traditionally associated with women, such as caregiving and household innovations, are often undervalued, as they challenge the established norms of what is deemed commercially viable or innovative (Lai, 2020). Furthermore, implicit biases in patent examination can result in less favorable outcomes for women, particularly in fields where male-dominated norms prevail (Porter, 2020). Studies reveal that women-led inventions are disproportionately rejected, especially those focusing on caregiving or women-specific needs. For instance, patents addressing women's health and caregiving technologies are often perceived as niche rather than impactful innovations, leading to systemic undervaluation within the patent review process (Subramani & Saksena, 2024). Such biases not only disincentivize women from engaging in patent-heavy fields but also hinder the development and recognition of solutions that address societal needs (Koning et al., 2021). Collaborative networks play a pivotal role in innovation and patent development, yet women are frequently excluded from these spaces. Male-dominated professional environments often limit women's access to influential networks, reducing their opportunities to engage in high-impact projects or co-develop patentable technologies (Porter, 2020). Moreover, women's underrepresentation in leadership positions within patent-heavy industries restricts their ability to

shape innovation agendas and advocate for inclusive practices (Vishnubhakat, 2014). These exclusions create a cycle where women remain marginalized in critical innovation processes, further entrenching gender disparities. Addressing these barriers requires systemic reform in education, workplace environments, and institutional policies. Promoting mentorship, revising biased frameworks in patent examination, and fostering inclusive learning and professional spaces are crucial steps toward creating equitable opportunities for women in STEM and patent-heavy industries. These changes not only enhance gender equity but also unlock the full potential of diverse perspectives in innovation.

IV. Engineering Education and Its Role in Addressing Disparities

A.The Influence of Engineering Education on Career Trajectories

Engineering education serves as a foundational step for gaining technical expertise. Early exposure to engineering concepts not only equips students with critical problem-solving skills but also encourages creativity and adaptability essential for success in patent-heavy industries. Already existing research highlights that incorporating hands-on projects and interdisciplinary approaches in early education helps develop a deeper understanding of engineering principles and their societal applications (Schuster et al., 2022). Programs that emphasize real-world problem-solving, such as robotics competitions and STEM camps, have been particularly effective in sparking interest and building confidence among students, especially girls (Stoet & Geary, 2018). A critical yet often overlooked component of engineering education is the potential for integration of intellectual property (IP) concepts. Evidence suggests that introducing IP into engineering curricula can empower women by connecting innovation with practical career applications and highlighting their contributions to patentable technologies (Vishnubhakat, 2014). Teaching IP concepts fosters a greater understanding of how engineering designs translate into tangible outcomes, such as patents and commercialization, which can motivate students to innovate and participate actively in research and development (Schuster et al., 2022). Creating inclusive and diverse engineering classrooms is another crucial avenue for fostering a sense of belonging among women.

B. Challenges in Engineering Education for Women

Women remain significantly underrepresented in engineering programs, accounting for only about 20% of engineering graduates despite achieving parity or majority in overall college enrollment (Stoet & Geary, 2018). This gap is exacerbated by societal perceptions that engineering is a male-dominated field, discouraging young women from pursuing technical disciplines (Koning et al., 2021). Limited access to engineering-focused courses in high school and a lack of female representation in faculty and leadership roles further perpetuate this disparity (Vishnubhakat, 2014). Implicit biases embedded in engineering education often marginalize women and other underrepresented groups. For example, course materials and examples in engineering textbooks frequently prioritize traditionally male-oriented industries,

such as automotive and aerospace, while neglecting innovations in caregiving or sustainable technologies where women have historically contributed (Schuster et al., 2022). Classroom dynamics can also reinforce stereotypes, with female students being undervalued in group projects or discouraged from taking leadership roles (Subramani & Saksena, 2024). These biases undermine women's confidence and hinder their academic and professional growth.

C. Strategies for Improvement

Improving education systems to make engineering programs more welcoming for women is essential to achieving gender equity and tapping into diverse talent. Targeted outreach initiatives have proven effective in inspiring girls to pursue engineering and other STEM disciplines. Programs like after-school STEM clubs, summer camps, and mentorship from female engineers provide hands-on experiences and relatable role models, helping to break down gender barriers (Porter, 2020). Efforts to engage young girls through activities that connect engineering concepts to real-world applications, such as sustainable energy or medical devices, can ignite interest and encourage long-term commitment to the field (Koning et al., 2021). Reforming engineering curricula to prioritize inclusivity and collaboration can create a more supportive environment for all students. Integrating case studies that highlight contributions from diverse engineers and encouraging interdisciplinary teamwork help challenge traditional norms and promote equitable participation (Schuster et al., 2022). Additionally, emphasizing societal impacts of engineering, such as addressing climate change or improving healthcare, can appeal to a broader range of students, including women, who are often motivated by the potential for societal contributions (Subramani & Saksena, 2024). Incorporating intellectual property education into engineering programs provides students with an overall understanding of how their technical skills can directly impact innovation and commercialization. Beyond fostering innovation, IP education introduces students to critical legal and economic aspects of engineering, such as protecting intellectual assets and navigating technology transfer processes. Evidence from academic patenting studies shows that when students are exposed to patent-related activities, such as drafting claims or analyzing existing patents, they develop a stronger appreciation for the practical applications of their work (Schuster et al., 2022). Programs that combine engineering projects with patentable outcomes, such as capstone courses where students identify patentable elements in their designs, not only enhance technical creativity but also instill confidence in navigating IP systems (Vishnubhakat, 2014). Additionally, integrating IP education fosters interdisciplinary collaboration, as students learn to approach innovation not only from an engineering perspective but also from business, legal, and societal angles. This cross-disciplinary approach can attract students, particularly women, who are motivated by the broader societal impacts of technology (Lai, 2020). By engaging with patent attorneys and innovators through workshops and real-world case analyses, students gain exposure to the full lifecycle of innovation, from ideation to commercialization. The inclusion of IP in curricula can also address disparities in patent-heavy industries by preparing students early for roles that involve patent filings and technology development. Addressing these challenges and implementing targeted

strategies can significantly improve the participation and retention of women in engineering, ultimately contributing to an increase in the number of women that are drawn towards a patent career.

VI. Future Research Directions

Future research should investigate the differences between female-led and male-led inventions to better understand how gender influences innovation processes and outcomes. Analyzing the types of inventions typically led by women versus men, as well as the commercial success and societal impact of these innovations, could provide valuable insights into how diverse perspectives contribute to technological progress. Additionally, studying the long-term impacts of inclusive engineering education on innovation is essential for assessing how educational reforms influence the development of diverse inventors. Longitudinal studies could track the career trajectories of students who experience inclusive and gender-equitable education, examining whether such environments foster more innovative and socially responsive patent outcomes. By addressing these gaps, future research can contribute to a more nuanced understanding of the interplay between gender, education, and innovation.

VII. Conclusion

The persistent underrepresentation of women in STEM fields, particularly in patent-heavy industries, underscores systemic challenges in education, workplace dynamics, and institutional structures. Addressing these barriers requires concerted efforts across multiple dimensions. Engineering education plays a pivotal role in shaping future innovators, and integrating intellectual property concepts within curricula can empower students, particularly women, to actively engage in innovation and commercialization. Promoting inclusivity through mentorship, outreach programs, and curricular reforms that highlight diverse contributions and societal impacts can foster a more supportive environment for women in engineering. Systemic changes in patent systems and workplace practices are equally crucial to ensure equitable recognition and opportunities. By bridging these gaps, we can unlock the potential of diverse talent, driving innovation and societal progress.

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