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Abstract

Female representation in mechanical engineering remains a critical challenge for academic institutions committed to fostering diversity and inclusivity. At Union College, the gender disparity is evident, with female enrollment in the Mechanical Engineering department declining from 22.5% in the freshman cohort to only 13.3% by senior year. To address this gap, the department has introduced initiatives aimed at supporting and retaining female students through structured mentorship, peer support, and career development programs. Key among these efforts is the Female Student Mentor Project, which pairs senior students with underclassmen to foster academic confidence and professional growth. Additionally, regular networking events and faculty mentorship provide essential guidance and role models, reinforcing a sense of belonging in the program. This paper analyzes the impact of these initiatives, drawing from student testimonials and qualitative coding analysis, to evaluate their effectiveness in addressing barriers to retention. The findings highlight the importance of mentorship, community support, and career exposure in improving female student engagement and persistence in mechanical engineering, offering insights into best practices for fostering gender equity in STEM.

1 Introduction

The underrepresentation of women in engineering remains a persistent challenge, affecting workforce diversity, innovation, and the long-term sustainability of STEM fields. Despite gradual progress, mechanical engineering continues to be one of the most male-dominated disciplines, with women comprising only 8.8% of professionals in the field [1]. This gender disparity begins early in the educational pipeline, where women account for just 18% of first-year engineering students in the United States, despite demonstrating comparable or superior performance in mathematics and science compared to their male peers [2].

Two primary factors influence female participation in engineering: recruitment and retention. Recruitment challenges stem from societal stereotypes, limited early exposure to engineering careers, and fewer opportunities for hands-on STEM engagement during primary and secondary education [3], [4]. Research highlights that young girls' interest in STEM declines as early as middle school, largely due to implicit biases in educational materials, the lack of visible female role models in engineering, and negative experiences such as peer harassment and gender bias [5], [6]. These factors contribute to the underrepresentation of women in engineering fields and create barriers that persist throughout their academic and professional journeys.

Retention, on the other hand, is influenced by institutional climate, academic support structures, and professional development opportunities. The Society of Women Engineers' (SWE) 2020 literature review underscores persistent disparities in engineering education and careers, including biases in hiring, career progression, and workplace culture [7], [8]. Women in engineering often experience microaggressions, exclusion from networking opportunities, and a lack of advancement into leadership roles, further discouraging long-term persistence in the field [9], [10]. Additionally, nearly 40% of female engineering graduates leave the profession within five years, often citing workplace culture, lack of mentorship, and career stagnation as key factors [11], [12].

At Union College, female enrollment in engineering programs reflects the national gender disparity. Biomedical engineering leads with an average female enrollment of 58%, followed by electrical engineering (26%), computer engineering (19%), and mechanical engineering (17%). In the Mechanical Engineering department, the gender gap is particularly evident, with the senior class comprising only four female students out of 30 (13.3%), while the freshman cohort shows a more promising increase in diversity, with nine female students out of 40 (22.5%). This discrepancy suggests that retention is a significant issue, as female representation declines through the later years of the program.

Given this decline, it is crucial to identify the barriers contributing to female student attrition and implement targeted institutional interventions to foster a supportive and empowering academic environment. To address these challenges, Union College has implemented initiatives such as mentorship programs, networking events, and outreach efforts. However, more structured interventions are needed to ensure that female students not only enter but also persist and thrive in mechanical engineering [13].

To combat these challenges, Union College has developed a multi-faceted support system, including the Female Peer Mentorship Program, which connects upper-level female students with underclassmen to provide academic and career guidance; Biannual Female Student

Meetings, fostering a sense of community through leadership workshops, alumni panels, and career discussions; industry mentorship and networking events, offering exposure to successful female engineers and potential career pathways; and enhanced academic support, including female faculty advisors, supplemental instruction roles for female students, and mentorship for high-attrition courses such as Thermodynamics and Solid Mechanics.

To assess the impact of these initiatives, this paper employs qualitative coding analysis of student testimonials and survey responses. Using the Braun and Clarke thematic coding framework [14], [15], [16], key themes have emerged, including the significance of mentorship in overcoming self-doubt, the role of peer networks in academic persistence, and the impact of structured career exposure on professional confidence. By analyzing these insights, this paper provides data-driven recommendations for strengthening female engagement in mechanical engineering.

This paper is structured as follows: Section 2 reviews the current landscape of female students in the Mechanical Engineering department at Union College, highlighting challenges and successes. Section 3 outlines the department's existing initiatives to support female students, including mentorship programs, academic assistance, and leadership opportunities. Section 4 presents qualitative findings based on testimonials and thematic coding analysis, offering insight into student experiences. Section 5 proposes future strategies to enhance female retention, improve academic confidence, and expand industry engagement. Section 6 concludes with recommendations for other institutions aiming to address gender disparities in engineering education. By emphasizing the importance of structured interventions and evidence-based policies, this paper provides a model for fostering gender equity in STEM education and professional development.

2 Current Landscape of Female Students in Mechanical Engineering Department at Union

2.1 Enrollment Trends:

Over the past four academic years (2021 to 2025), female representation in the Mechanical Engineering program at Union College has fluctuated across class levels, highlighting persistent challenges in retaining female students. As illustrated in Table 1, the sophomore class currently has the highest female representation at 33.3%, while the senior class has the lowest at 13.3%. Specifically, the senior class consists of only four female students out of 30, marking a notable decline in female participation as students progress through the program. A closer look at this group reveals that some initially enrolled female students switched to other disciplines, such as Biomedical Engineering—where female representation is nearly 50%—or even non-STEM fields like History, citing challenges in the rigor and culture of the program. Additionally, a few female students left college altogether, further contributing to the decline in female retention within Mechanical Engineering. In contrast, the freshman class demonstrates a promising increase in diversity, with a female ratio of 22.5% (9 out of 40 students), while the junior class includes 10 female students out of 53 (18.9%).

This trend underscores the urgent need for targeted retention strategies, particularly to support female students during their transition to upperclassman years. Establishing an

inclusive academic culture and strengthening support systems are essential to improving retention rates and fostering gender equity in engineering education.

Table 1: Current Female and total student enrollment in Mechanical Engineering at Union College in 2025.

Class Level	Female Students	Total Students	Female Ratio (%)
First Year	9	40	22.5
Sophomore	16	48	33.3
Junior	10	53	18.9
Senior	4	30	13.3

Table 2: Retention ratio of the freshman to senior in the last 8 years

	Female			Male			Female to total graduation Ratio (%)
Class Level	First-year	Senior year	Retention Ratio (%)	First-year	Senior year	Retention Ratio (%)	
2014-2018	6	4	67	54	42	78	9
2015-2019	4	3	75	55	48	87	6
2016-2020	8	7	88	35	33	94	18
2017-2021	7	6	86	40	34	85	15
2018-2022	11	13	118	34	25	74	34
2019-2023	10	11	110	43	31	72	26
2020-2024	5	3	60	44	39	89	7
2021-2025	10	4	40	33	26	79	13

2.2 Retention Trends:

Table 2 provides an analysis of retention rates for female and male students in the Mechanical Engineering program at Union College over the past eight years. The data tracks the number of students at the first-year and senior levels, calculates retention ratios (i.e., the percentage of first-year students who persist through senior year), and examines female-to-total graduation ratios.

Key observations include:

- **Female Retention:** Retention rates for female students vary significantly, ranging from a low of 40% (2021-2025 cohort) to a high of 118% (2018-2022 cohort). Retention rates exceeding 100% suggest factors such as transfer students or delayed graduations.
- **Male Retention:** Male retention ratios are generally higher and more consistent, ranging from 72% to 94% across the cohorts.
- **Female Graduation Representation:** The female-to-total graduation ratio provides insight into the overall gender balance at graduation, with percentages varying from 6% to 34% over the eight-year span.

The analysis of enrollment and retention trends in Union College's Mechanical Engineering department indicates that while there is encouraging diversity at the freshman level, female student retention remains a challenge. Declining retention rates suggest the need for sustained intervention efforts, including improved mentorship, professional development opportunities, and a more inclusive academic environment. Strengthening institutional support systems is critical to ensuring female students not only enroll in but also thrive and graduate from mechanical engineering programs.

2.3 Reasons Behind the Attrition:

While enrollment and retention trends provide valuable insights into the challenges faced by female students, it is equally important to understand the underlying reasons contributing to their decisions to leave the Mechanical Engineering program. . Discussions with six female students at Union College who left the program between 2020 and 2025 have highlighted several factors that influence attrition. Although the sample size is small, their experiences represent a broad spectrum of challenges that contribute to the overall trend of female attrition in mechanical engineering. Some of these challenges align with findings from broader research on female retention in STEM fields, reinforcing existing literature on gender disparities in engineering. These factors, spanning from external societal pressures to internal academic challenges, can be grouped into five key categories:

1) Cultural Expectations and Societal Biases

Cultural norms and societal biases significantly influence women's decisions to pursue careers in male-dominated fields like mechanical engineering. Societal and familial pressures often steer women toward disciplines perceived as more "appropriate" for them, such as healthcare or social sciences, thereby limiting their career choices and fostering a sense of alienation in engineering. Moreover, the lack of visible female role models exacerbates this issue; without relatable figures, many students struggle to envision a successful future in the field. For example, a study commissioned by McLaren Automotive and Plan International found that 61% of schoolgirls desire more female role models in engineering to inspire their pursuit of STEM careers [17]. Additionally, research indicates that women engineers and engineers of color continue to face pervasive biases in hiring, pay, promotions, and evaluations [18]. Enhancing female representation and visibility is essential for creating an inclusive and supportive academic environment.

2) Lack of Awareness about Career Opportunities

Many female students are unaware of the diverse and rewarding career paths that mechanical engineering offers. Without sufficient exposure to industry professionals—especially female role models—students may struggle to see the long-term potential of their degrees. This lack of career-related guidance can diminish motivation and contribute to higher attrition rates. For example, a study by the American Society of Mechanical Engineers (ASME) reported that, as of 2022, only 17.3% of four-year mechanical engineering degrees were awarded to women [19]. Additionally, research commissioned by McLaren Automotive and Plan International found that 61% of schoolgirls desire more female role models in engineering to inspire their pursuit of STEM careers [17]. Addressing this gap through targeted mentorship and industry engagement is essential for improving retention. Furthermore, expanding internship

opportunities and increasing industry partnerships can provide students with real-world applications of their skills, making the discipline more tangible and attractive.

3) Academic Challenges and Course-Specific Difficulties:

The demanding curriculum of mechanical engineering, when combined with insufficient support systems, can leave female students feeling isolated and overwhelmed. As coursework intensifies, the lack of tailored mentorship and academic resources further undermines their ability to cope with the rigorous demands of the program. Specific courses within the Mechanical Engineering curriculum, such as Thermodynamics, Fluid Mechanics, and Solid Mechanics, are particularly challenging for some female students. For instance, one student dropped out before her junior year despite strong overall performance because she struggled significantly with Thermodynamics 1. This case exemplifies how course-specific difficulties can erode self-confidence and lead to attrition when students feel overwhelmed or disconnected from the material. Research indicates that dissatisfaction with particular courses is a key factor in engineering attrition among female students [20].

Beyond course difficulties, internalized societal stereotypes contribute to lower self-efficacy and higher fear of failure, which negatively impact persistence [21]. Many female students hesitate to ask for help, fearing it will reinforce gendered perceptions of competence gaps. Without visible academic support systems, these challenges can lead to disengagement and eventual withdrawal from the program. Structured academic interventions are essential to mitigate these challenges and improve retention. Research has shown that female students who receive mentorship from female role models report increased confidence, a stronger sense of belonging, and higher persistence rates in engineering programs [22]. By implementing targeted academic support systems, Union College can strengthen retention, build student confidence, and ensure female students thrive in mechanical engineering.

4) Perception of Competence Gap and Self-Efficacy

Many female students report feeling that they are less capable than their male peers, despite performing at a comparable academic level. This perceived gap in competence often stems from societal stereotypes that position men as more "naturally" suited for technical fields like mechanical engineering. Such perceptions can lead to self-doubt, reducing their sense of belonging within the program. Additionally, female students may hesitate to ask questions in class, fearing their inquiries will be perceived as “stupid” or assuming that their male peers already know the answers. This reluctance to engage academically can hinder their overall performance and limit their involvement in class discussions. Research indicates that female students in mechanical engineering often exhibit lower self-efficacy compared to their male peers, despite achieving similar or higher academic performance. Research found that undergraduate women in engineering tend to have lower self-efficacy despite earning higher grades than men [23]. This disconnect between self-perception and actual performance can be particularly pronounced in physics courses, which are integral to mechanical engineering curricula. Research has found that female students in Mechanical Engineering often maintain similar or higher GPAs than male students but exhibit lower self-efficacy, particularly in physics courses [24]. This disconnect is particularly evident in physics-heavy courses, which form the foundation of mechanical engineering curricula. Addressing this

challenge requires fostering a growth mindset, integrating confidence-building initiatives, and ensuring that faculty provide an encouraging and inclusive learning environment.

The decision of female students to leave the Mechanical Engineering program is influenced by a combination of academic, cultural, and personal factors. Addressing these challenges through enhanced mentorship, industry engagement, structured academic support, and confidence-building initiatives is critical to fostering a supportive environment that promotes long-term retention and success. By implementing targeted interventions, Union College can help bridge the gender gap in mechanical engineering and ensure that female students not only enter the field but also thrive within it.

3 Activities Taken for Female Students in Mechanical Engineering

To improve the retention of female students in Mechanical Engineering, Union College has implemented various initiatives aimed at addressing the key challenges identified through discussions with students who left the program. These efforts focus on confidence-building, representation, academic support, career awareness, and course-specific assistance.

3.1 Combating Cultural Expectations and Societal Biases

Research indicates that female role models in STEM significantly improve retention and academic performance among female students. At Union College, female faculty play a key role in enhancing the sense of belonging for female students, particularly in the early stages of their academic journey. Supportive faculty who set high expectations, offer personalized feedback, and engage students in research contribute to building academic resilience. Female students report stronger support from faculty compared to their male peers, with 82% of women identifying positive faculty interactions, compared to 53% of men [5]. Additionally, female faculty members serve as mentors, offering guidance on career development, research opportunities, and strategies for navigating male-dominated fields.

(i). Representation of Female Faculty

Union College's Mechanical Engineering department currently has a higher proportion of female faculty (33.3%) than the national average of 19.6% (SWE 2024). This enhanced representation not only challenges traditional stereotypes but also provides students with diverse role models who have succeeded in a traditionally male-dominated field. Female faculty serve as mentors in both formal and informal settings by hosting office hours, leading research projects, and participating in departmental events. Their visibility in the classroom and in leadership roles has been shown to improve academic performance and retention rates among female students [25]. Additionally, by participating in outreach programs and speaking at conferences, these faculty members extend their influence beyond the campus, further reinforcing the potential for success among female engineers.

(ii). Assigning Female Advisors:

Since 2023, the department has implemented a policy of assigning female faculty advisors specifically to female students. This initiative is designed to create a cohesive support system from the very beginning of a student's academic journey. Grouping first-year female students under the same advisor fosters peer support and camaraderie while easing the transition to college life. These advisors provide personalized academic guidance, help students navigate

course selection, and offer career development advice tailored to the unique challenges women face in engineering. Faculty observations suggest that such targeted advising significantly enhances academic performance and emotional well-being [26]. This initiative has also facilitated the development of small group mentoring sessions, where students share experiences and strategies to overcome both academic and personal challenges.

(iii). Female Peer Mentorship

Cultural expectations and societal biases continue to deter women from pursuing and remaining in mechanical engineering. Many female students face implicit and explicit messages that engineering is a "male-dominated" field, leading to feelings of self-doubt. The Female Peer Mentorship Program at Union College plays a key role in challenging these stereotypes by fostering a community of support, empowerment, and representation.

Initially launched in 2019, the program connected juniors and sophomores through departmental funding for informal meet-ups. These interactions provided academic and personal guidance while offering mentors valuable leadership and problem-solving experience. Temporarily halted due to the COVID-19 pandemic, the program is set to be revitalized in 2025 with renewed funding and a structured mentoring approach. By fostering engagement and mutual support, the mentorship program strengthens the sense of community within the Mechanical Engineering department. It pairs upper-level female students with first- and second-year mentees, creating a safe space for guidance and skill-building. Research shows that peer mentorship increases self-efficacy, boosting confidence and problem-solving abilities [27]. Exposure to successful female mentors reinforces the belief that women can thrive in mechanical engineering.

Through structured guidance and networking, the Female Peer Mentorship Program helps combat societal biases, bridge the competence gap, and enhance academic support, fostering an inclusive environment where female students feel empowered to succeed.

3.2 Increasing Awareness of Career Opportunities

A key challenge for female students is the lack of awareness regarding the diverse and rewarding career paths available in mechanical engineering. To address this, the department has introduced initiatives aimed at broadening career perspectives and inspiring confidence in the field.

(i). Alumni Panels and Workshops

Regularly organized alumni panels and career workshops serve as an invaluable resource for students by providing direct insights into real-world engineering careers. These events feature successful female graduates who share their experiences, discuss challenges they have overcome, and offer guidance on career advancement. Exposure to diverse career trajectories—ranging from technical roles to leadership positions—broadens students' understanding of the field's potential. Research indicates that such career exposure enhances self-efficacy and motivation, leading to increased persistence in STEM disciplines [19], [22]. Beyond career insights, the interactive nature of these sessions allows students to

engage with alumni, ask questions, and build connections, fostering a strong professional network. The department also incorporates industry panels, resume-building workshops, and mock interviews, ensuring that students are well-prepared for internships and full-time roles.

(ii). Encouraging Participation in the Society of Women Engineers (SWE):

Union College actively promotes female student involvement in the Society of Women Engineers (SWE), recognizing its role in providing career resources, mentorship, and leadership development. SWE membership grants access to national conferences, technical workshops, and exclusive networking opportunities, equipping students with industry connections and career readiness skills. On campus, SWE hosts events such as technical training sessions, guest speaker seminars, and leadership development workshops, helping students refine both technical expertise and soft skills. Informal gatherings, such as "Dinner and Discussion" sessions and movie nights, create a supportive community where students can exchange experiences and advice. Furthermore, SWE's emphasis on community outreach and service initiatives—such as hosting STEM workshops for local schools—strengthens students' professional profiles while emphasizing the real-world impact of engineering. Participation in SWE not only enhances career preparedness but also cultivates confidence, fosters a sense of belonging, and reinforces long-term commitment to the field. Through these initiatives, Union College ensures that female students gain the exposure, mentorship, and professional development opportunities necessary to thrive in mechanical engineering and confidently pursue rewarding careers.

3.3 Addressing Academic Challenges and Course-Specific Difficulties

The rigorous curriculum of mechanical engineering requires targeted academic support to help female students navigate complex coursework, build confidence, and develop essential problem-solving skills. Union College has implemented structured initiatives to address these challenges effectively.

(i). Peer Female Peer Mentorship

Building a strong peer network fosters collaborative learning and emotional support, which is essential for academic success and retention. Union College facilitates structured study groups and informal peer interactions, creating an environment where students can exchange strategies, clarify doubts, and reinforce technical concepts. Research indicates that positive peer interactions significantly enhance persistence in STEM fields by promoting accountability and shared learning experiences [5]. Collaborative learning helps students feel more integrated into the program, reducing feelings of isolation and self-doubt. Establishing peer networks ensures that students receive both academic and motivational support, which is vital for persistence in a challenging discipline like mechanical engineering.

(ii). Course-specific Mentorship

Mentorship plays a critical role in academic support, helping students overcome course-specific challenges. The department has established multiple mentorship strategies, including pairing upper-level female students with first-year students to offer academic guidance, study techniques, and time management strategies. This structured approach

ensures that incoming students receive guidance from peers who have successfully navigated similar challenges.

Additionally, course-specific mentorship pairs experienced students or alumni with mentees to provide targeted assistance for challenging subjects like Thermodynamics, Fluid Mechanics, and Solid Mechanics. These mentorship relationships help students develop problem-solving strategies and confidence in tackling difficult coursework. Furthermore, faculty-assigned female advisors provide personalized guidance on course selection, academic strategies, and career alignment, ensuring that students are equipped to manage demanding subjects effectively.

(iii). Promoting Female Supplemental Instructors and Tutors

To bridge the competence gap and reinforce technical proficiency, the department actively encourages female students to serve as Supplemental Instructors in foundational mechanical engineering courses. Female Supplemental Instructors conduct structured review sessions for high-attrition courses, offer one-on-one tutoring, and lead group discussions to provide additional academic reinforcement. Supplemental Instructors are highly effective in improving student outcomes, as they provide targeted support and enhance understanding of complex engineering concepts. Beyond academic instruction, female Supplemental Instructors serve as role models, demonstrating that women can excel in technical subjects and provide leadership in engineering education. Students appreciate having female role models in these instructional roles, as it fosters a sense of belonging and encourages more women to pursue and persist in engineering. By increasing female representation in instructional roles, this initiative helps break down stereotypes and fosters a more inclusive learning environment. Encouraging more women to take on these instructional positions also ensures that female students have relatable role models within their academic journey. Addressing the Perception of Competence Gap.

A strong belief in their ability to succeed is essential for female students to persist in STEM majors [28]. Confidence-building initiatives play a crucial role in counteracting societal stereotypes and implicit biases that often undermine women's self-efficacy in male-dominated fields [29]. To foster a supportive environment and reinforce the idea that women are equally capable in engineering disciplines, Union College has implemented targeted strategies aimed at addressing the perception of a competence gap.

(i). Alumni Panels and workshop

Exposure to successful female engineers helps students overcome the perception of a competence gap by providing tangible role models. Union College's alumni panels and career workshops connect students with accomplished female graduates, offering insights into career trajectories, challenges faced, and strategies for professional growth. These events highlight the diverse opportunities within mechanical engineering, from technical roles to leadership positions, reinforcing the notion that success is achievable regardless of gender.

A notable example is an alumna who graduated 20 years ago with a BS in Mechanical Engineering from Union College. Through mentorship, continued learning, and persistence, she transitioned from structural analysis into management. Her journey, shared during alumni panels, exemplifies the importance of adaptability and growth, reassuring students

that success is possible despite initial setbacks or doubts. Research suggests that exposure to successful female role models enhances self-efficacy, a key factor in encouraging women to persist in engineering fields [26], [28]. Additionally, female alumni who pursued graduate studies share how advanced degrees furthered their careers and helped them navigate academic and professional challenges. These discussions emphasize the broad range of career possibilities and inspire students to view themselves as future leaders in the industry.

(ii). Female Peer Mentorship

Peer mentorship is a highly effective strategy for addressing the competence gap by providing female students with structured support and opportunities to develop technical and problem-solving skills [28]. The Female Peer Mentorship Program at Union College pairs upper-level female mechanical engineering students with first- and second-year students, offering guidance, encouragement, and hands-on learning opportunities.

One of the keyways peer mentorship directly addresses the competence gap is through technical skill development. Many first-year female students enter mechanical engineering with less prior exposure to engineering tools, software, and hands-on projects than their male peers. Peer mentors help bridge this gap by guiding mentees through SolidWorks, MATLAB, lab work, and design projects, reinforcing their technical capabilities and boosting their confidence in applying engineering principles [26]. Beyond academics, peer mentorship provides essential emotional and social support, which is crucial for female students in male-dominated fields. Many students experiencing self-doubt or imposter syndrome find reassurance through mentors who validate their experiences, offer encouragement, and share effective strategies for overcoming challenges. Studies indicate that structured mentorship programs significantly enhance female students' confidence and increase their retention in STEM fields [30]. Furthermore, mentors benefit from the program as well, as guiding younger students strengthens their own leadership, communication, and advocacy skills. This reciprocal relationship fosters a culture of support, empowerment, and skill-building, helping to close the competence gap while reinforcing professional growth.

By implementing these comprehensive initiatives, Union College is actively working to foster an inclusive, empowering environment that supports the academic and professional growth of female Mechanical Engineering students. These efforts are crucial for addressing the multifaceted challenges these students face and for narrowing the gender gap within the field.

(iii). Encouraging Participation in the SWE

Union College actively promotes female student involvement in the Society of SWE as a means to address confidence gaps and foster professional development. SWE provides members with access to mentorship networks, national resources, and leadership workshops, equipping students with essential skills for career advancement. Through on-campus initiatives such as technical training, leadership development sessions, and networking events, SWE helps students develop problem-solving abilities, build confidence, and expand their professional connections. Informal sessions like “Dinner and Discussion” events and industry speaker panels further cultivate a supportive community where female students can share experiences and strategies for overcoming challenges. Moreover, SWE’s engagement in community outreach and STEM education initiatives reinforces the real-

world impact of an engineering degree, demonstrating to students that their skills are valuable and applicable. Research shows that involvement in professional organizations significantly improves female students' persistence and engagement in engineering disciplines [27].

4 Outcomes and Student Perspectives on Female Success

4.1 Success of Female Students in the Mechanical Engineering

Female students in the Mechanical Engineering department at Union College consistently excel in various domains. Their achievements span academic excellence, leadership and mentorship, athletic prowess, and interdisciplinary exploration—each reflecting their well-rounded development, resilience, and capacity to challenge traditional gender stereotypes in engineering.

4.1.1 Academic Excellence

Female students consistently achieve high academic performance throughout the program. A significant percentage maintain GPAs above 3.5—56% of sophomores, 40% of juniors, and 75% of seniors—compared to their male counterparts (42% of sophomores, 26% of juniors, and 30% of seniors). Each year, at least one female student attains a perfect 4.0 GPA, showcasing exceptional talent. This consistent academic excellence reflects not only mastery of a rigorous curriculum but also the growing confidence and resilience of these students as they progress through the program. Their achievements serve as a powerful counter-narrative to prevailing gender stereotypes in STEM and emphasize the importance of fostering an inclusive academic environment.

4.1.2 Leadership and Mentorship

Female students at Union College are at the forefront of leadership both within the Mechanical Engineering department and across campus. In student organizations such as the Baja Club, Aero Club, and Rocket Club, they demonstrate advanced problem-solving skills, teamwork, and hands-on engineering expertise. Leaders like the Co-President of the Baja Club and the President of the Aero Club guide innovative projects and drive competitive success in traditionally male-dominated settings. Beyond departmental organizations, female students hold influential roles in campus-wide groups such as the Society of Women Engineers (SWE) and Engineers for a Sustainable World (ESW). Their leadership in these organizations supports advocacy, mentorship, and professional development. Initiatives like the Pi Tau Sigma help desk sessions and the Supplemental Instructor (SI) program further reinforce this leadership culture by providing peer mentoring and academic support. These efforts not only benefit individual academic performance but also strengthen a supportive network that empowers female students to mentor and inspire one another.

4.1.3 Athletic Achievement

Athletic success is another hallmark of female engineering students at Union College. These students demonstrate exceptional time-management skills and resilience by balancing rigorous academic demands with competitive sports. For instance, Maren Friday, the captain of the hockey team, maintains a perfect 4.0 GPA while excelling on the ice, exemplifying leadership and commitment. Similarly, Lauren Armstrong's achievements in track—

competing in shot put, hammer throw, and javelin, setting personal bests, and qualifying for championships—reflect her discipline and multifaceted talent. First-year student Olivia Cunningham, a member of the women's basketball team, also illustrates how athletic involvement reinforces academic persistence and fosters a sense of belonging, further proving that supportive environments enable women to excel in traditionally male-dominated arenas.

4.1.4 Interdisciplinary Exploration

Union College's liberal arts framework encourages female Mechanical Engineering students to pursue interdisciplinary studies, which enrich their technical education with diverse perspectives. Many students complement their engineering major with double majors or minors in fields such as English, Theater, Mathematics, Creative Writing, and Music. This integration enhances critical thinking, communication skills, and cultural awareness while providing access to academic environments that may be less male-dominated. By approaching complex problems from multiple angles, these students develop innovative solutions and emerge as well-rounded engineers prepared for a globalized workforce.

Collectively, these outcomes illustrate the multifaceted success of female students in the Mechanical Engineering department at Union College. Their achievements in academics, leadership, athletics, and interdisciplinary studies not only challenge existing gender stereotypes but also reinforce the importance of a supportive and inclusive environment that promotes gender equity in engineering.

4.2 Student Testimonials and Qualitative Analysis

To gain deeper insight into the female student experience in the Mechanical Engineering program at Union College, we collected testimonials from students across all academic years. These firsthand accounts reveal the challenges, triumphs, and growth that characterize their academic journeys. To systematically analyze these narratives, we applied a structured coding data method, following the framework established by Braun and Clarke [14], Nowell et al. [15], and Saldaña [16]. This methodological approach is well-documented in qualitative research and is commonly employed to ensure the rigor and trustworthiness of qualitative findings.

Initially, during **open coding**, each testimonial was reviewed line-by-line to extract significant statements and identify recurring ideas related to academic challenges, mentorship, and support. Next, in the **axial coding** phase, these initial codes were organized into broader thematic categories—such as overcoming initial self-doubt, the importance of mentorship and peer support, and the role of extracurricular engagement in fostering a sense of belonging. Finally, through **selective coding**, we refined these themes into a coherent narrative that reflects how Union College's initiatives help female students bridge the perceived competence gap and thrive both academically and personally. This process enabled us to extract and synthesize recurring themes that illustrate the impact of departmental initiatives on fostering confidence, peer support, and a sense of belonging. Our coding approach and the resultant themes are supported by a robust body of literature [31], [32], ensuring that our findings are both valid and reliable.

4.2.1 First-Year Perspectives

A first-year student and varsity basketball team member described her initial experiences:

"I enrolled as a mechanical engineering student at Union, aware of the challenges ahead but with great ambition for my future... Coming into my first term, I felt confident in my academic abilities, but also overwhelmed by the thought that my peers had already gained vast experience in engineering. Thankfully, I was surrounded by peers in the same boat. This common ground connected us, transforming perceived gaps in our knowledge into motivation for higher academic success... The supportive environment, especially through my involvement with varsity sports, has reinforced the idea that I belong here."

Thematic Insights:

- **Initial Self-Doubt and Overcoming Uncertainty:** This narrative reflects the common anxiety among first-year students about limited prior technical experience [27].
- **Peer Support and Community:** Early peer interactions are shown to mitigate feelings of isolation and bolster academic confidence [33].

4.2.2 Sophomore Perspectives

Sophomore testimonials provide valuable insights into the impact of informal mentorship and supportive peer networks in overcoming challenges in a male-dominated field. One student noted:

"As a girl growing up, I was not encouraged to participate in STEM-focused activities like my male peers... The feeling of starting at a disadvantage is common for women in STEM."

This reflection underscores the internalized pressures many female students face before even entering college. Another student emphasized the transformative role of mentorship:

"*Following a professor's recommendation, I attended a Union College Baja team meeting. There, I met Binney Patton, who recognized leadership potential in me that I hadn't yet seen in myself. Her support transformed my initial self-doubt into a drive to excel."*

An international sophomore shared her experience regarding cultural and familial expectations:

"I was met with comments like, 'Are you sure? That's such a rough job,' or suggestions to consider 'more suitable' alternatives. Yet, coming to Union College erased those doubts and allowed me to see my potential."

Another sophomore student highlighted the importance of faculty support and professional development opportunities:

"An integral part of my success as a Mechanical Engineering student has been the support of female faculty members. Taking Engineering Statics was a turning point. When I struggled with my first midterm, my professor proactively reached out, offering extra support and study strategies. Their guidance helped me regain confidence and perform better throughout the course. Beyond academics, I was encouraged to attend the SWE Conference, which was transformative. Being surrounded by over 20,000 women in engineering, meeting professionals in leadership roles, and attending career workshops broadened my perspective on what's

possible. The experience strengthened my ambition and prepared me for future career opportunities."

Thematic Insights:

- **Mentorship as a Catalyst for Confidence:** Both informal and structured mentoring relationships play a pivotal role in helping sophomores overcome self-doubt [5], [34]. Faculty and peer mentors provide guidance that empowers students to recognize their potential and navigate academic challenges.
- **Cultural and Familial Challenges:** The international perspectives emphasize the additional layer of cultural expectations female students must navigate, and how institutional support can counterbalance these pressures [26].
- **Professional Development and Networking Opportunities:** Attending workshops and industry conferences exposes students to role models, leadership pathways, and career-building strategies. Engaging with professional networks such as SWE enhances confidence, expands career possibilities, and strengthens students' commitment to engineering.

4.2.3 Junior Perspectives

A junior student, actively engaged in engineering teams such as SAE Aero and Baja SAE, emphasizes the importance of hands-on experiences and peer mentorship:

"My first experience with engineering was on a high school robotics team, so transitioning to college was a significant change. However, being part of teams like SAE Aero and Baja provided me with familiar ground and access to older peer mentors, especially women, who gave me critical advice when coursework became challenging... The support from these teams has not only helped me adjust but also enabled me to mentor younger students, reinforcing the idea that everyone can learn and grow."

Thematic Insights:

- **Bridging the Technical Gap:** Experiential learning and team-based projects effectively supplement formal education and help mitigate disparities in prior technical exposure [35].
- **Reciprocal Mentorship:** Mentoring younger students reinforces the mentors' confidence and leadership skills, as exemplified by paired peer learning initiatives where both parties enhance their problem-solving skills and technical competence through collaborative engagement [36].

4.2.4 Senior Perspectives

Senior students reflect on the long-term impact of early support and mentorship. One senior, who holds leadership roles in organizations such as SWE and ESW, shared:

"My path to choosing a career in mechanical engineering was filled with uncertainty and self-doubt, particularly due to the male-dominated environment I experienced in high school. At Union, I almost considered switching majors, but supportive interactions with my academic advisor changed everything. Over time, through persistent mentoring and a strong sense of

community, I rebuilt my self-confidence. Now, I actively mentor other female students, drawing on the experiences that helped me overcome my own challenges."

Thematic Insights:

- **Long-Term Impact of Mentorship:** Early and sustained mentorship emerges as a critical factor in overcoming self-doubt and fostering persistence, echoing the work of Estrada et al. [37].
- **Community and Role Models:** The narratives underscore that a robust support network—reinforced by successful role models—is essential for long-term success in navigating the challenges of a male-dominated field, aligning with research by Eby *et al.* [38].

In summary, the analysis of student testimonials reveals that Union College's initiatives—particularly effective mentorship, robust peer support, and an inclusive community—play a vital role in helping female students overcome early self-doubt and navigate the challenges of a male-dominated field. These qualitative insights underscore that early and sustained support not only enhances academic confidence but also fosters leadership, resilience, and long-term persistence in mechanical engineering. Collectively, these findings highlight the critical importance of institutional support in promoting gender equity in STEM.

5 Recommendations for Future Initiatives

To further support and empower female students in Mechanical Engineering, we propose several targeted initiatives that build on existing successes while emphasizing the critical role of peer programs in fostering community, mentorship, and professional growth.

5.1 Female Group Meeting

To cultivate a strong sense of community and mutual support, we propose establishing regular Female Group Meetings. These termly gatherings—held three times a year—will serve as an inclusive platform for networking, mentorship, and leadership development. Key activities will include:

- ***Networking Events & Guest Speakers:*** Inviting distinguished female engineers and leaders to share their experiences and insights.
- **Leadership Workshops:** Equipping participants with essential skills to excel both academically and professionally.
- **Awards Luncheon:** Celebrating the achievements of female students and faculty across academic, research, athletic, and leadership domains.

A dedicated Female Engagement Committee, comprising representatives from all class levels and faculty advisors, will oversee the initiative. Currently, six students have volunteered to organize this committee, ensuring that the program is closely aligned with the diverse needs of female students. These meetings are designed not only to foster peer interaction but also to create a sustainable culture of empowerment and inclusivity within the department.

5.2 Female Student Mentor Project

The Female Student Mentor Project is a cornerstone recommendation that leverages the power of peer programs. This initiative aims to provide structured, one-to-one mentorship by pairing senior students with sophomores and juniors with first-year students. The key functions of this peer mentorship program include:

- **Personalized Guidance:** Offering academic support, career development advice, and strategies to navigate challenges in a male-dominated field.
- **Skill Development:** Mentors and mentees both benefit, as mentors reinforce their own leadership and communication skills while mentees gain confidence and technical competence.
- **Social Integration:** Regular check-ins, team-building activities, and informal interactions (supported by a modest budget for dinners or coffee meetings) help to build a strong, supportive network.

Based on current enrollment, we plan to form 16 mentor-mentee pairs between seniors and sophomores and 10 pairs between juniors and first-year students. With an estimated annual budget of $1,300, this initiative will be integral to improving retention, boosting confidence, and enhancing academic success among female students.

5.3 Expanding Female Career Perspectives

Broadening career perspectives is essential for empowering female students to envision long-term success in engineering. We recommend several initiatives designed to strengthen industry connections and enhance career-oriented mentorship:

- **Industry Mentor Programs:** Establish partnerships with leading organizations (e.g., GE Vernova, National Nuclear Laboratory, National Grid) to create mentorship opportunities with female professionals.
- **Career Panels and Workshops:** Organize events featuring successful female engineers who can share their career journeys, discuss gender-specific challenges, and provide practical advice.
- **Site Visits and Networking Events:** Facilitate events such as a dinner discussion with industrial leaders and site visits to companies, which offer students real-world insights and the opportunity to engage with industry experts.

These career-focused initiatives will complement the Female Student Mentor Project by extending mentorship beyond academic support into professional development. By connecting students with industry leaders and alumni, these efforts will help female students navigate career challenges and confidently transition into the workforce.

6 Conclusion

Fostering gender inclusivity and empowering female students in the Mechanical Engineering Department at Union College is an ongoing and dynamic process. This paper has identified key challenges—such as the perception of a competence gap, cultural biases, academic rigor, and limited career exposure—and has showcased successful strategies that promote female

student success. Our findings, supported by both quantitative data and qualitative testimonials, underscore the critical roles of supportive faculty, effective peer mentorship, and inclusive community-building in enabling female students to thrive in a traditionally male-dominated field.

The proposed initiatives—Female Group Meetings, the Female Student Mentor Project, and efforts to Expand Female Career Perspectives—are designed to create a robust support network. These initiatives will provide female students with the necessary tools, resources, and professional connections to excel academically, professionally, and personally. Emphasizing collaboration, empowerment, and leadership development, the recommendations aim to foster a genuine sense of belonging and community.

The sustained success of these programs will rely on active engagement from both students and faculty, coordinated through a dedicated Female Engagement Committee and strengthened by strategic partnerships with industry leaders. Together, these efforts not only enhance the academic and professional trajectories of current female students but also pave the way for a successful transition into the engineering workforce, equipped with the confidence, skills, and networks essential for long-term success.

By implementing these recommendations and maintaining a steadfast commitment to inclusivity, Union College can continue to narrow the gender gap in engineering, ensuring that future generations of female students have every opportunity to excel and lead in the field of mechanical engineering.

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