

The Effect of Male to Female Ratios on Female Students in Engineering and Technical Science Majors

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Abstract

According to an article written by fictiv corporation, 16.1% of employed persons in architecture and engineering positions in the US in 2022 consists of women. This study examines perceptions of male and female students in engineering classes particularly focusing on the impact of the female-to-male ratio on female students. The study presents survey results shedding light on the students' perceptions within group settings. By exploring these dynamics, the research aims to contribute to a better understanding of gender dynamics in engineering education. Focusing on first-year engineering students at Author's University*, the impact of the gender distributions in teams during fall semester projects is analyzed. In a first-year program comprised of an introduction to engineering design course focused on the engineering tools and applications and a communications course emphasizing teamwork and design skills, this study employs an anonymous survey to gather perspectives from students in various team gender-composition categories: Majority Male, Majority Female, All Male, All Female, and Even Gender. The survey questions cover participant's gender identification, group composition, communication effectiveness, perceived respect, and confidence in expressing opinions. Responses, collected in 2022 and 2023, highlight consistent challenges faced by female students in majority male groups. Consequently, female students reported lowest levels in all categories when placed in a majority male group in both cohorts, 2022 and 2023. Future research will expand the survey to upper-level classes and explore diverse engineering concentrations. Once the factors that contribute to the low percentage of female engineering graduates are identified, we hope to be able to foster increased participation and persistence of female identifying students in engineering and technical sciences.*

Hypothesis - Male to female ratios in group settings affect how female students will succeed in engineering and technical science majors.

Background Information

At *University*, only about 24% of students majoring in engineering identify as women. International data from the OECD (Organization for Economic and Co-Operational Development), who sends out surveys each year to over 80 countries, underscores a significant gender gap in engineering and information technology (ITC) fields with 3 out of 4 students in engineering and 4 out of 5 students in ITC being men (Morera et al., 2019). Despite women outperforming men on the Science Performance (PISA) test, a STEM based assessment offered to high schoolers, a staggering 60% of women exit engineering careers, citing issues related to pay and promotion disparities (Morera et al., 2019). Understanding why women face challenges in engineering majors and encounter wage discrepancies in the workforce, despite their demonstrated aptitude, is paramount.

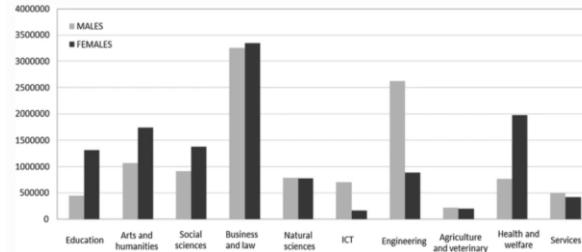


Figure.1: Statistics Taken from Eurostat on the Male-to-Female Ratio in Different Professions (Morera et al., 2019)

Numerous studies have delved into the unique experiences of female students in comparison to their male counterparts. Research indicates that female students encounter higher rates of gender harassment, (defined as any intimidating, offensive, or hostile behavior that disrupts their academic pursuits or campus comfort) particularly within STEM environments (Rincon et al., 2016). These hostile climates surrounding stereotypical assertions of female inadequacy deepen gender divides, ultimately hindering female success and well-being (Rincon et al., 2016). Notably, a study conducted at Virginia Tech examined the impact of sexist cues on female students' performance. Participants, including both high-achieving women and men, were randomly assigned to either an "easier" or "more difficult" exam group. Contrary to expectations, the difficulty level of the test did not differ between conditions. However, the instructions in the group exposed to sexist cues amplified stereotype threats against women's abilities, resulting in lower test scores compared to their male counterparts (Bell et al., 2003).

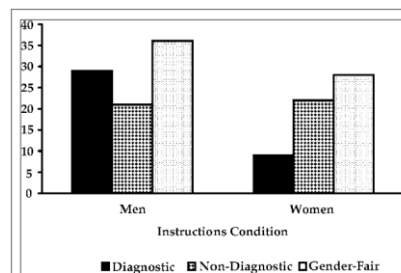


Figure.2: Graph illustrating Female Students' Performance Relative to Male Students under Different Exam Instruction Conditions Exams (Bell et al., 2003)

Subsequent iteration of the study, featuring identical test difficulty levels but varied exposure to sexist cues, consistently yielded similar outcomes. Once again, women exposed to sexist cues reported heightened stereotype threats and exhibited lower test scores.

Understanding the impact of environmental factors, such as exposure to gender stereotypes and harassment, is crucial in creating an inclusive and constructive learning environment for all students in engineering classes. By investigating the outcomes experienced by female students in groups of varying female-to-male ratios, my research directs toward the overarching goal. Shedding light on existing group dynamics will allow educators and administrators to more effectively address disparity and create environments that allow all students to thrive. Ultimately, this research aims to present potential strategies and policies that may promote equality and support the success of all students in engineering education.

Methods

The study focuses alone on understanding the perspective of primarily first-year engineering students enrolled in an introduction to engineering program. Data was collected primarily during the completion of a reverse engineering project, wherein students analyze different type of devices (flashlights, thermometers,

electrical pencil sharpeners, etc.) and deconstruct their mechanisms, served as the primary method to collect data. Surveys were administered in consecutive years, during Fall 2022 and Fall 2023, following the completion of the project. Each semesters' data was analyzed separately to accommodate potential shifts in perspectives due to varying time frames and circumstances. The survey encompasses a range of questions to gain insights into students' experience within their project groups. These questions inquired about gender identity, group composition, project outcomes, and perceptions of group dynamics. Notably, students were asked to evaluate aspects of their educational success, such as their comfort level in participating in group discussions, the quality of communication and collaboration within their groups, and their sense of respect during group interactions. Additionally, an open-ended question encouraged students to share any additional comments or experiences related to their participation in group projects and their perceptions of how the male-to-female ratio may influence these experiences. The answers students provided to the open-ended question were omitted from the paper to protect the students' identity, as the personal experiences could be connected back to the student.

Questions
Which of the following most closely fits your gender identity?
How many Group Members were there in your project?
How many male-identifying group members were in your group?
How many female-identifying group members were in your group?
What grade did you receive for the completed group project?
How comfortable did you feel speaking up and participating in group discussions related to the project?
How would you rate the overall communication and collaboration within your group during the project?
Did you feel respected during group conversations?
Was the work in the group split up evenly?
Do you have any additional comments or experiences related to your participation in group projects and how they may be affected by the male-to-female ratio?

Figure 3. Questions Asked Included in Survey Sent to Students in Both 2022 and 2023

Figure 3 displays the specific questions included in the survey distributed to students in both 2022 and 2023. Of particular relevance were responses pertaining to group communication, perceived respect from group members, and confidence in expressing opinions, which were rated on a 1-5 scale. A higher rating indicated a positive perception, such as effective communication, feeling respected, or being comfortable speaking up. The survey was conducted anonymously using Google Forms to encourage participation and ensure honest responses.

The responses from female and male students were analyzed separately, facilitating a more detailed examination of how perspectives may vary based on the female-to-male ratio within group settings. This approach enabled a focused analysis of any shifts or patterns in responses attributable to gender dynamics within project groups. Data analysis was conducted using Excel to organize and interpret the survey responses effectively. This analysis aimed to uncover insights into the influence of gender composition of student experiences and outcomes within collaborative engineering projects. This study seeks to contribute to the development of informed strategies and policies that promotes inclusivity and equitable opportunities for all students in engineering education.

Data and Analysis

For the fall semester of 2022, the data collection encompassed a notable larger participant pool (n=51) in contrast to the student involvement observed during the fall semester of 2023 (n=30).

Questions
What gender do you identify as?
What is the number of male identifying students in your group?
What is the number of female identifying students in your group?
How comfortable do you feel speaking up in your group?
How well does your group communicate?
Do you feel respected by your group members?

Figure 4. Survey Questions for Data Analysis Sent to Students in Both 2022 and 2023

Figure 4 showcases the inquiries posed in the questionnaire distributed to all participating students.

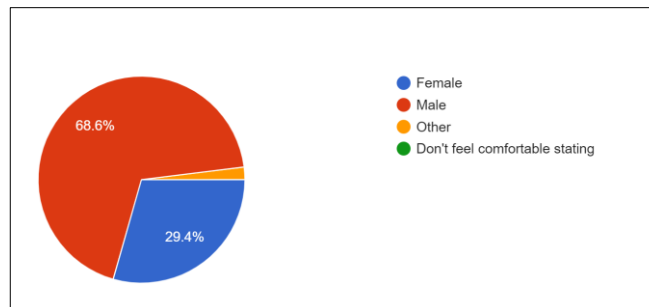


Figure 5. Percentage of Female to Male Students Participation in Fall 2022

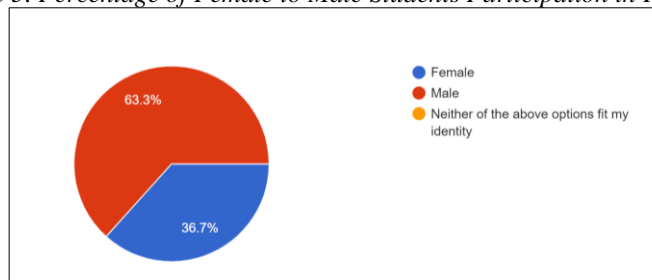


Figure 6. Percentage of Female to Male Students Participation in Fall 2023

The distribution of female-to-male students remained consistent across the fall semester of 2022 and 2023, as indicated in Figure 5 and 6. While our study primarily centered on female students, the substantial

representation of male participants prompted a detailed examination of group dynamics, accounting for their respective gender compositions, as illustrated in Figures 7 and 8.

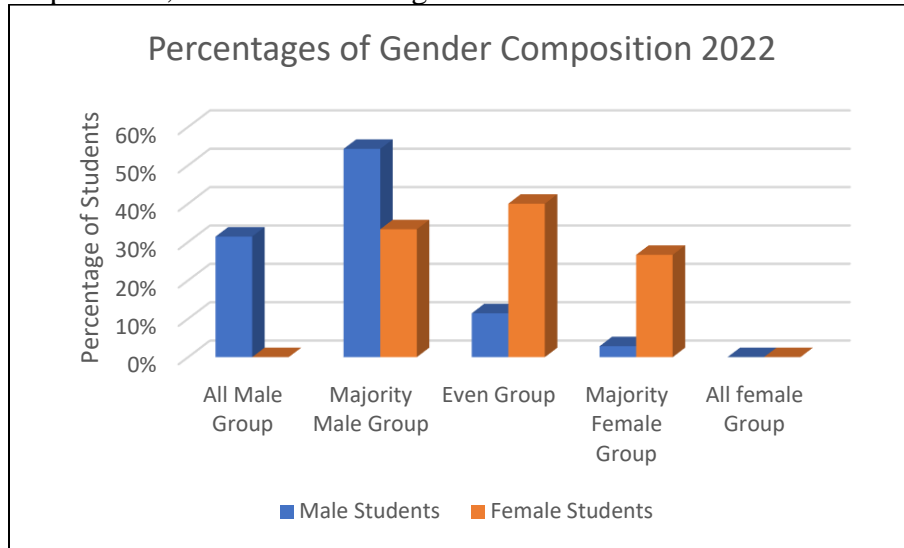


Figure 7. Percentage of Students in Each Group from the Fall Semester of 2022

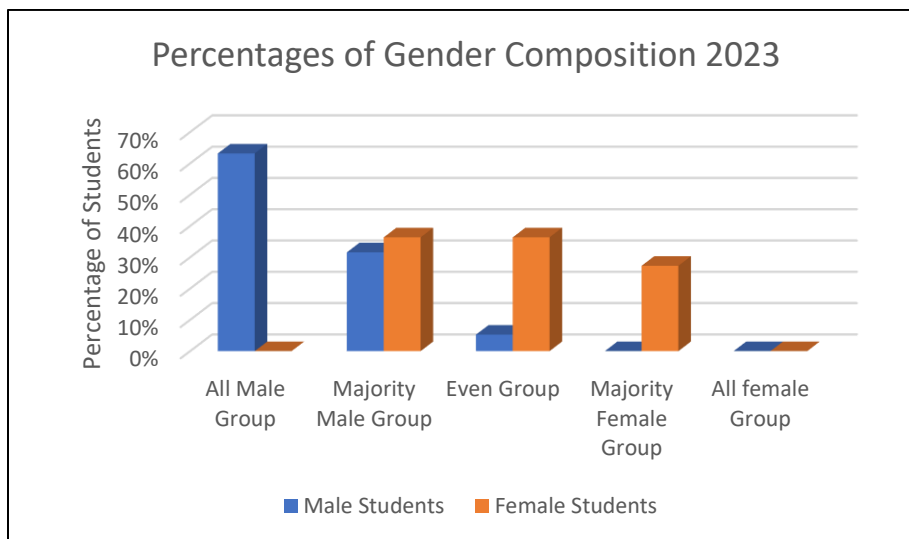


Figure 8. Percentage of Students in Each Group from the Fall Semester of 2023

Although the groups were randomly assigned, the limited number of responses in both years prevented a comprehensive representation of groups with varying ratios of female-to-male identifying students. Notably, a significant difference observed from 2022 to 2023 was the absence of male-identifying students in majority female groups participating in our 2023 survey. Additionally, there were no responses from female-identifying students in all-female groups in either year. In 2022, there was a higher proportion of male-identifying students in majority male groups, while in 2023, there was an increase in all male groups. This data holds significance, particularly considering the primary focus of this study on interpreting female perspectives. Consequently, groups exclusively comprising male-identifying participants would offer limited insights relevant to the study’s objective.

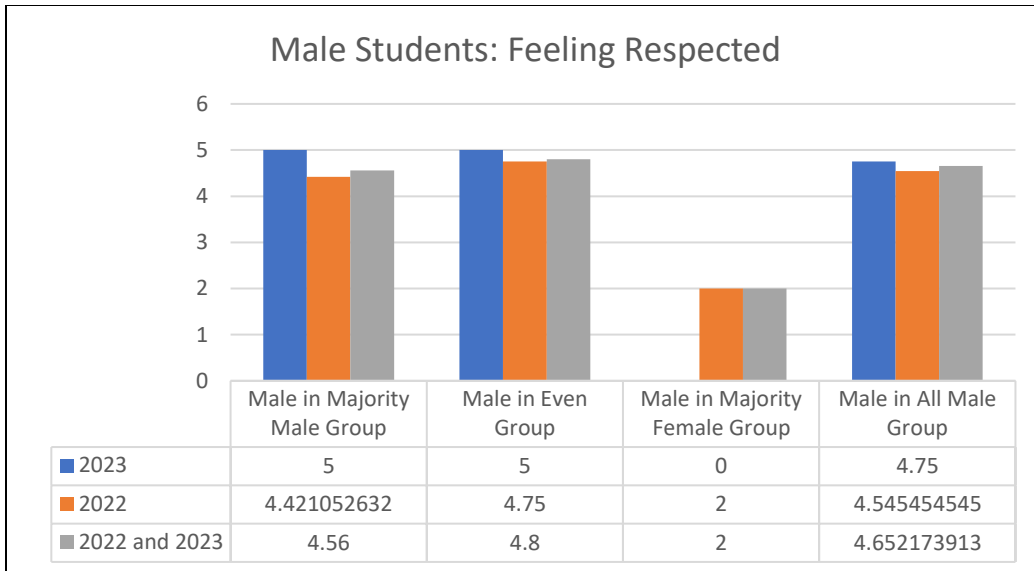


Figure 9. Analyzed Data of how Respected Male Students Felt in Their Respective Groups

Figure 9 demonstrates the perception of respect among male students, measured on a scale of 1 to 5 (x-axis), with 1 indicating minimal perceived respect from their peers, across various group compositions. The data presented represents the average responses of male students within each group during the fall semesters of both 2022 and 2023. In 2022, male students reported feeling the most respected within evenly balanced groups, while experiencing the least perceived respect in majority female groups. Respect levels were relatively consistent across all-male and majority-male groups during this period. Similarly, in 2023, male students expressed the highest sense of respect within groups characterized by an even male-to-female ratio. Conversely, they felt the least respected within majority female groups, with perceptions of respect remaining relatively steady across all-male and majority-male groups. Combining the data from the 2022 and 2023 reveals consistent trends, indicating that the perception of respect among male students remained unchanged between the two years.

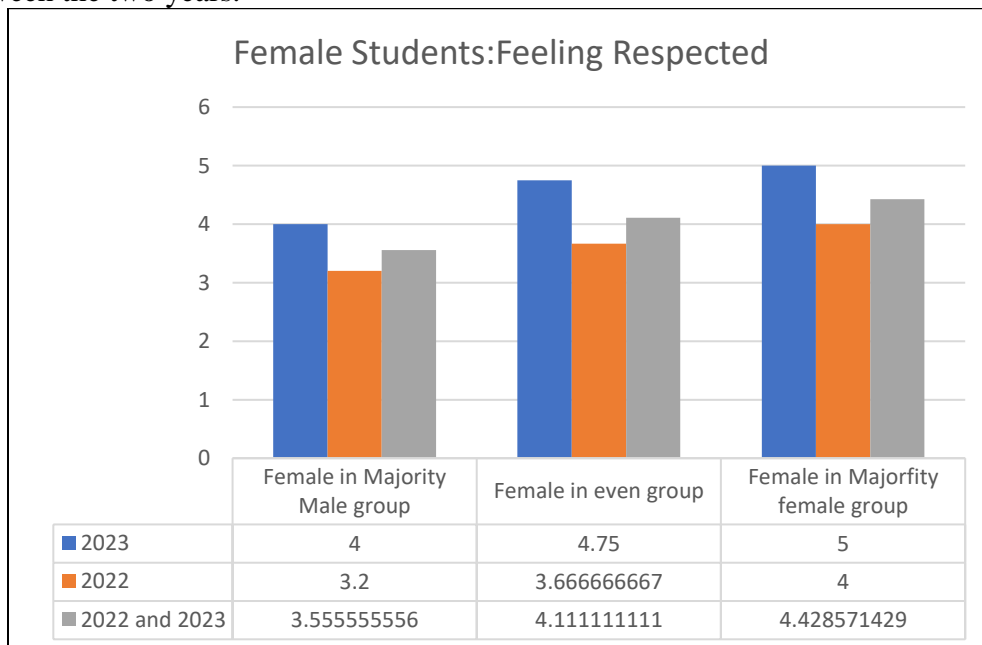


Figure 10. Analyzed Data of how Respected Female Students Felt in Their Respective Groups

Figure 10 depicts the correlation between female perceptions of received respect and the gender composition of groups. As with the analysis conducted in Figure 9, this data represents the average responses of female students within each group during the fall semesters of both 2022 and 2023. In 2022, female students reported feeling most respected in majority female groups and evenly balanced groups, while experiencing the least perceived respect in majority male groups. Notably, majority male and all-male groups were omitted from this dataset as no female students participated in surveys within these group compositions. Similarly, the analysis of 2023 mirrors these findings, reinforcing the consistency across the two years. Consequently, the combined analysis of data from 2022 and 2023 yields consistent results, reaffirming the observed patterns in female perception of received respect relative to group gender compositions.

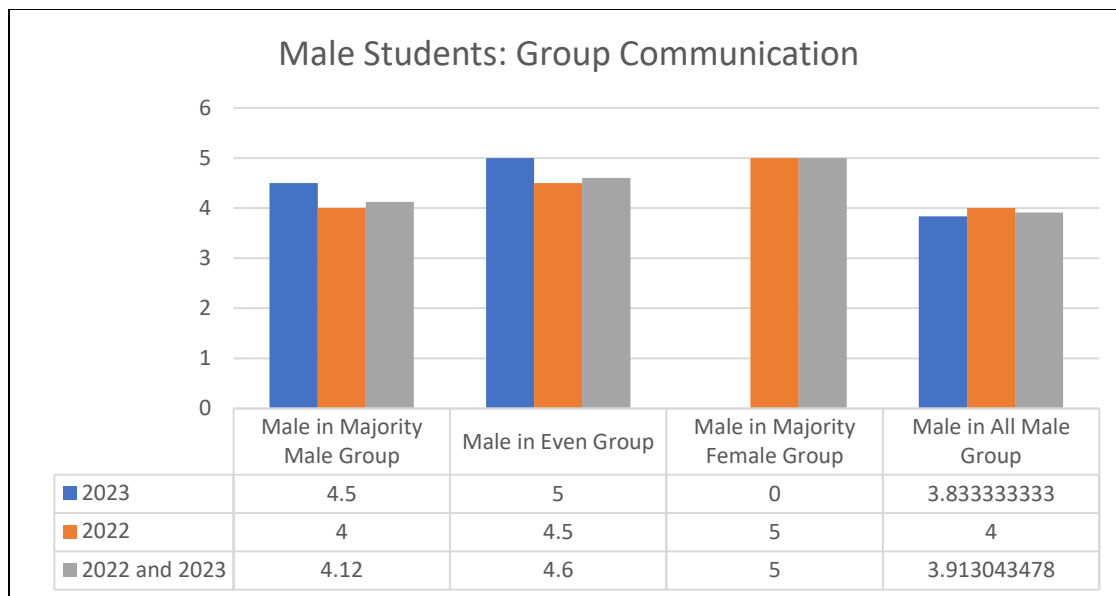


Figure 11. Analyzed Data of How Male Students Rated Group Communication

Figure 11 illustrates the perception of group communication among male students, rated on a scale from 1 to 5, with 1 representing minimal communication within the group. In 2022, male students indicated that they experienced the most effective group communication within majority female and evenly balanced groups, while perceiving communication as less effective within majority male and all-male groups. Moving to 2023, male students reported the highest perception of group communication within evenly balanced groups, achieving a perfect average score of 5. Notably, there were no male students in majority female groups during the 2023 period. Upon combining the data from 2022 and 2023, a consistent pattern emerges. Male students consistently reported the highest levels of group communication with majority female and evenly balanced groups, while perceiving communication as less effective within majority male and all-male groups.

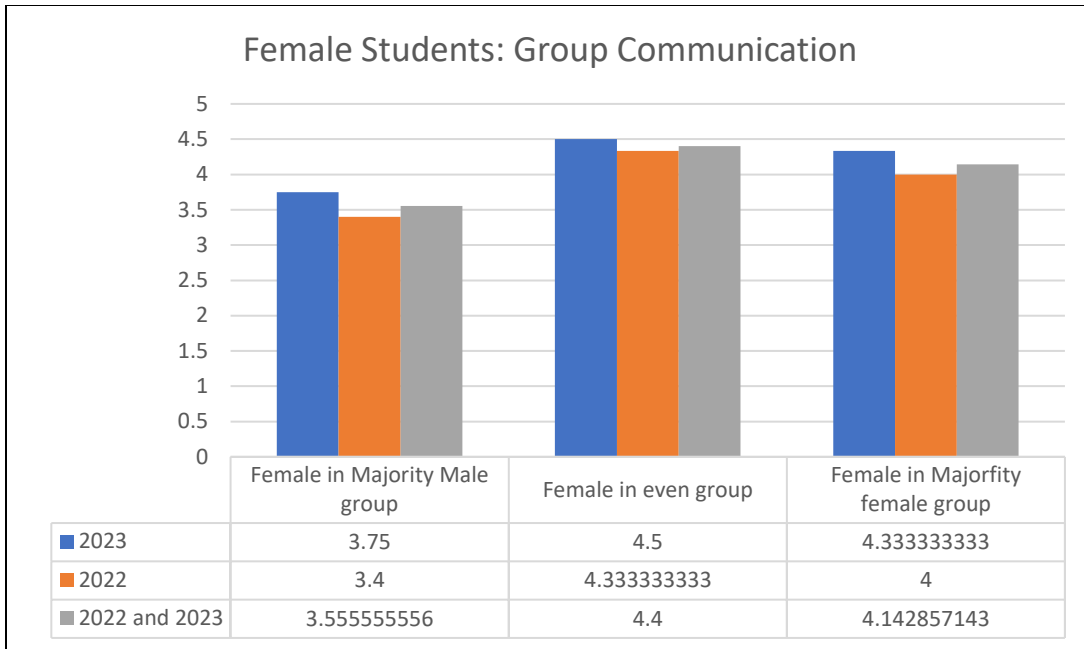


Figure 12. Analyzed Data of How Female Students Rated Group Communication

Figure 12 delves into the correlation between female students’ perceptions of group communication and the gender ratio within their groups. Notably, female students reported the most effective communication in groups with an even ratio of female to male students, while perceiving communication as less effective in majority male groups. When average data from both 2022 and 2023, a consistent trend emerges. Female students consistently rated communication within their groups as optimal when the gender ratio was evenly balanced. However, there was slight variation in perception, as the combined analysis indicated that female students viewed communication as most effective specifically in even ratio groups.

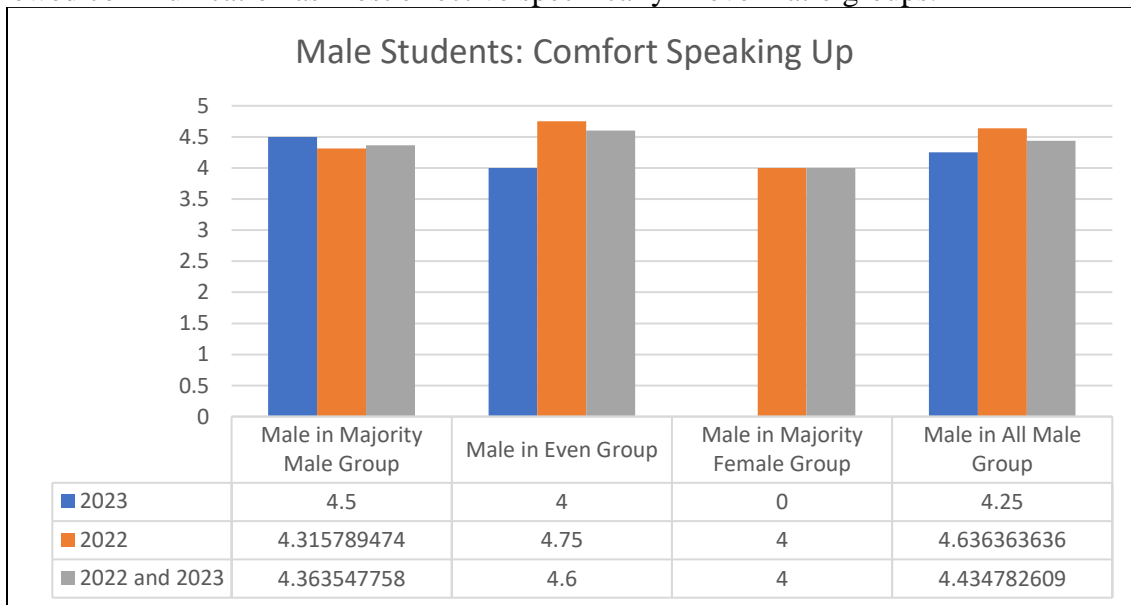


Figure 13. Analyzed Data of How Male Students Felt Speaking Up in Their Respective Groups

Figure 13, demonstrates the perception of comfort in speaking up among male students, measured on a scale of 1 to 5, with 1 representing minimal comfort in voicing opinions with their peer groups, across various

group compositions. The data provided represents the average responses of male students within each group during the fall semester if both 2022 and 2023. In 2022, the analysis reveals that male students felt most at ease speaking up in groups characterized by an even distribution of female and male students. Conversely, they reported feeling least comfortable speaking up in both majority male and majority female groups. In 2023, male students expressed the highest level of comfort speaking up in majority male groups. However, there were insufficient responses from male students in majority female groups to derive an average comfort level. Integrating the data from 2022 and 2023, a consistent trend is analyzed. Male students consistently felt more comfortable expressing themselves in groups where the gender distribution was even.

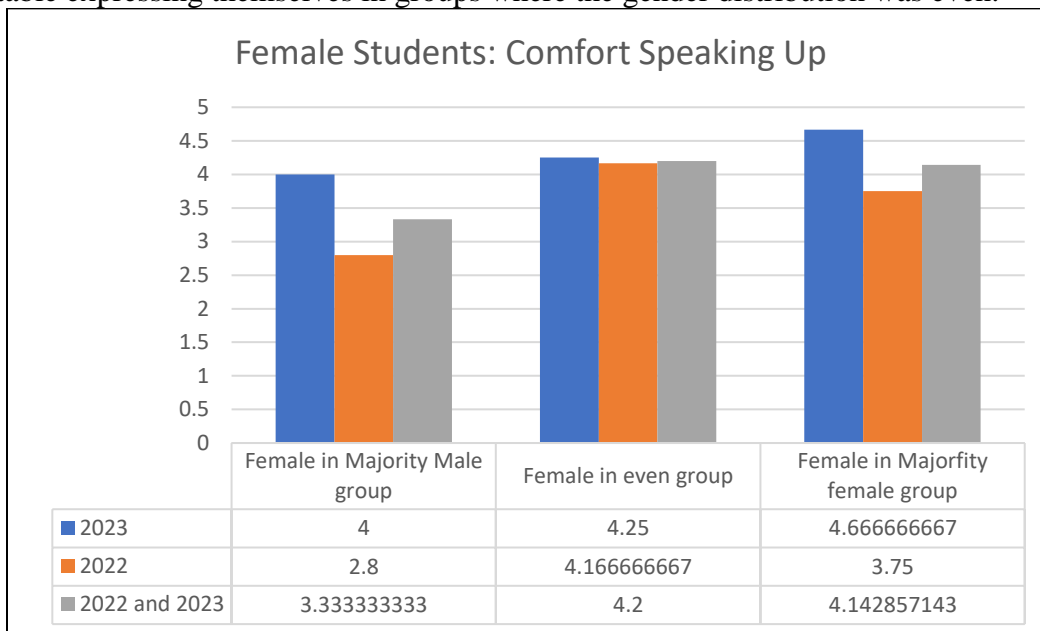


Figure 14. Analyzed Data of How Female Students Felt Speaking Up in Their Respective Groups

Figure 14, displays how comfortable female student felt speaking up in their groups on a scale 1 to 5, where 1 was the minimal level of comfort. In 2022, female students felt most comfortable speaking up in evenly distributed groups with an average of 4.167/5. Female students felt least comfortable sharing their ideas in majority male groups with an average of 2.8/5. In 2023, female students had recorded the highest level of comfort in speaking up in majority female groups, but they still viewed majority male groups as the least comfortable ratio to speaking up in. In the combined data analysis of 2022 and 2023, female students felt the most comfortable speaking up and talking about their idea in an evenly distributed group.

Future Research

This data oversaw the acquisition of perspective from two different cohorts and, remarkably, the data from both consistently aligned with our initial hypothesis. However, to conduct thorough statistical testing and ensure the robustness of our findings, it is imperative to gather a more extensive dataset. To address this limitation, future endeavors will involve a broader distribution of surveys, extending beyond our current academic institution to encompass other colleges and schools with comparable first year programs. This strategy will maintain uniformity in the content addressed and manner by which questions are prompted.

While the survey was conducted anonymously to encourage broader participation, our forthcoming research endeavors will incorporate an additional dimension that correlates students' project grades with their survey responses. This methodological approach seeks to recognize a potential association between students' perception of group dynamics and their academic outcomes. By quantifying these associations, we aim to

enhance the integrity of our statistical analyses and deepen our understanding of the factors influencing students experiences within group settings.

Furthermore, our research scope will extend to younger grade levels, specifically targeting students in 5th to 7th grades. By examining how gender ratios in group settings interact with age-related development factors, we aim to define potential differences in students' attitudes and academic capabilities across different stages of their educational journey. The data amassed from these investigations will garner valuable insights into the multifaceted dynamics of gender composition that will broaden the significance of this study.

Conclusion

The underrepresentation of females in obtaining bachelor's degrees in engineering compared to their male counterparts is a well-documented phenomenon. This study sought to delve into the possibility that the environment within which female students operate impacts their ability to excel in engineering courses, a dynamic potentially distinct from that experienced by their male counterparts. To explore this hypothesis, a comprehensive survey was distributed among students enrolled in Engineering Design and Division 104 and 111 during the fall semesters of both 2022 and 2023. Each participant was categorized into different group settings based on gender ratios, including even (comprising an equal number of females and males), majority female, all male, and majority male groups. The survey aimed to capture students' experiences within group work settings, providing insights into the nuance of their interactions and perceptions. Upon collection of survey data, a meticulous quantification process ensued, enabling a detailed analysis of the participants' experiences. In the subsequent Data and Analysis section of the paper, we discerned a clear correlation between the ratio of female to male students within groups and the performance of female students in STEM classes. Notably, our examination of bar graphs depicting responses to various survey questions revealed that female students reported the lowest levels of confidence in expressing their opinions, group communication effectiveness, and perceived respect levels when placed in majority male groups. The initial discovery prompted us to extend our data collection efforts into a second year, driven by the desire to further explore and validate our findings. We are enthusiastic about incorporating innovative methodologies in future research endeavors to gather more comprehensive and robust data. While a discernible trend has emerged from our preliminary analysis, unraveling the definitive obstacles faced by women in this male-dominated field demands sustained inquiry, with a focus on accruing additional time, participants, and data. By committing to this ongoing investigation, we aspire to foster a deeper understanding of the challenges encountered by female students in engineering education and to contribute meaningfully to initiatives aimed at promoting gender equity within STEM disciplines.

Citations

- BELL, A. M. Y. E., SPENCER, S. T. E. V. E. N. J., ISERMAN, E. M. M. A., & LOGEL, C. H. R. I. S. T. I. N. E. E. R. (2003). Stereotype threat and women's performance in engineering. *Journal of Engineering Education*, 92(4), 307–312. <https://doi.org/10.1002/j.2168-9830.2003.tb00774.x>
- Danyelle Tauryce Ireland Associate Director of the Center for Women in Technology and Research Assistant Professor in the Engineering and Computing Education Program. (2022, September 13). *Only about 1 in 5 engineering degrees go to women*. The Conversation. Retrieved December 8, 2022, from <https://theconversation.com/only-about-1-in-5-engineering-degrees-go-to-women-185256>
- Evans, C. (2024, January 2). *Women in engineering statistics: 32 notable facts*. Fictiv. <https://www.fictiv.com/articles/women-in-engineering-statistics-32-notable-facts>
- How anxiety affects men and women differently*. How Anxiety Affects Men and Women Differently. (n.d.). Retrieved December 8, 2022, from [https://www.texashealth.org/Health-and-Wellness/Behavioral-Health/How-Anxiety-Affects-Men-and-Women-Differently#:~:text=Women%20are%20twice%20as%20likely,than%20men%20\(14.3%20percent\)](https://www.texashealth.org/Health-and-Wellness/Behavioral-Health/How-Anxiety-Affects-Men-and-Women-Differently#:~:text=Women%20are%20twice%20as%20likely,than%20men%20(14.3%20percent)).
- Rincón, B. E., & George-Jackson, C. E. (2016). Examining department climate for Women in Engineering: The role of stem interventions. *Journal of College Student Development*, 57(6), 742–747. <https://doi.org/10.1353/csd.2016.0072>
- Salas-Morera, L., Ruiz-Bustos, R., Cejas-Molina, M. A., Olivares-Olmedilla, J. L., García-Hernández, L., & Palomo-Romero, J. M. (2019). Understanding why women don't choose engineering degrees. *International Journal of Technology and Design Education*, 31(2), 325–338. <https://doi.org/10.1007/s10798-019-09550-4>