

## The subtle ostracism faced by women in engineering: has anything changed?

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**ABSTRACT:** Women in engineering continue to face obstacles throughout their engineering degree. Universities attempt to increase the numbers of women entering the programme, however, the number of women graduating from engineering continues to be less than 20%. This research sought to identify if there are still challenges experienced by female undergraduate and graduate students that contribute to the systemic issue of inequity throughout post-secondary degree programmes at a medium-sized institution through gender-nonspecific inquiries. A total of 372 students actively participated in a 21-question cross-sectional mixed-method survey. Three themes were identified relating to culture, gender and personhood. The built environment created physical barriers, while the attitudes of male peers, teaching assistants and professors led to negative experiences. Stereotypes and the lack of role models influenced one's sense of belonging and led to feelings of imposter syndrome. Attitudinal shifts are required to encourage the engagement and successful completion of women in post-secondary programmes.

**Keywords:** STEM; culture, women in engineering, ostracism, misogyny

### INTRODUCTION

The number of women graduating in the predominantly male field of science, technology, engineering and mathematics (STEM) continues to be a minority (19.7%) [1]. Excluding military roles, the culture within engineering has historically been known as one of the most sex-segregated professions [2], where females face many obstacles ranging from underlying stereotypes to physical restrictions in certain environments. The constant stereotyping of women in engineering is an impediment to their success and persistence in the programme [3] as these negative judgments based on a *devaluing* stereotype that are still prevalent in today's environment, impact the performance of students [3].

While many are aware of the inequities that exist, the university environment continues to propagate inequity. In educational settings, female students are faced with having to adapt to the engineering culture and the masculinity of that culture, aligning themselves despite the masculine activities that are associated [4]. When women voice their opinions, dismissive behaviours often occur from male students who are unaware of the hurtful nature of their responses. Moss-Racusin et al found that females are more likely to perceive sexism than men as they are the most likely to be exposed [5]. A loss of sense of belonging accompanied by insecurity about women's *place in engineering* can ultimately lead to ostracism and cases of imposter syndrome. Ostracism leads to a threatened sense of self [6]. Being taught by professors who use male pronouns along with the lack of female faculty members, leads to negative thoughts that manifest in a feeling of imposter syndrome. Dennehy and Dasgupta found that a sense of belonging and self-efficacy had a more significant impact on the outcome of a female's retention and career in STEM than a strong performance in the programme [7].

Creating environments that are welcoming to all and are free from stereotypes is important but *avoiding negativity* does not constitute action for change. The objective of this study was to identify the challenges experienced by current female engineering students that contribute to the systemic issue of inequity. The authors focused on the local problem of how attitudinal barriers within the Faculty of Engineering and Applied Science affect learning and how they continue to persist.

### METHOD

A 21-question survey was distributed to undergraduate and graduate students who were studying engineering at a medium-sized university [8][9]. Multiple-choice questions were used to provide quantitative results, while open-ended

questions allowed for qualitative thematic analysis. Ethics approval was granted by the University Research Ethics Board. As part of the ethics approval, survey participants were told that specific quotes would not be included in the publication of this survey to avoid fear of reprisal. Thus, quotes presented are paraphrased versions of the students' actual wording.

## Participants

Of the active participants, 29 were graduate engineering students and the remaining 343 were undergraduate engineering students. There were 223 students who self-identified as females (60%), 127 as males (34%), seven who identified as other or preferred not to say their gender (2%) and 16 who did not respond to the gender question (4%). Persons who selected *Other* or *Prefer not to say* are not displayed separately to ensure anonymity within this limited number of respondents. The age of the participants ranged from 18 to 48 years old.

## Data Collection and Analysis

The data was collected on-line via the Qualtrics Experience Management Software platform. A device with Internet connection was required for participation. The survey's first question verified that the participants read the Letter of Information and the Consent form to the survey. The next 20 questions were presented one at a time with the option to go forward or back in the survey. Each student received the questions in the same order, and multiple-choice answers followed the same order among participants. After completing the survey, it was submitted anonymously for analysis.

Data were separated into three categories for analysis: first-year students, years 2-4, and graduate students. Each question was analysed by comparing those persons who self-identified as females versus males, as well as evaluating questions with subsections (for a multiple choice question, how many males vs. females picked a, b, c or d). Every open-ended question response was labelled relative to the spreadsheets (engineering student 23 was line 23). The qualitative responses were then analysed within NVivo 12 Plus, where themes were coded by two authors (JH, SvE) independently.

## RESULTS

Survey results were analysed quantitatively in Excel and qualitatively through NVivo 12 Plus. The qualitative analysis identified three thematic areas: culture, gender and personhood (Figure 1).

### Culture of the Programme

When asked *What is your favourite part of your programme?*, 71 students (23M, 48F) of 375 responded *the community* or *the family atmosphere*, but both the built environment and the attitudes of peers, teaching assistants and professors led to negative experiences for female undergraduate and graduate students.

**Environment:** The built environment within engineering was identified as an obstacle. Students found that in stressful situations, such as examinations, access to a women's washroom in the building in which they were writing their examination was either non-existent or not known to the moderators. Another environmental issue identified by the students was the lack of access to steel-toe boots. Some students rent boots to reduce expenditures especially if only being used for one or two classes, but small sizes are not available. Identifying artefacts that support the idea that women do not belong in certain spaces and addressing the associated issues appears to be an essential step in a move toward reducing barriers. Students believe that discriminatory environmental barriers are one of the easiest to address. A more challenging aspect is the significant attitudinal barriers that contributed to feelings of inequity.

**Attitudes:** Experiencing dismissive behaviours from group members and the feeling of being overlooked was evident. Fifty-five percent of students reported feeling discouraged in their programme. Twelve specific comments were made by females who found male peers dismissive when they challenged sexist behaviours. Students believed that the *male culture* was reinforced by professors who perpetuated gender stereotypes by focusing on male pronouns when providing examples and case studies.

Male respondents commented that everyone experiences issues that include the need to advocate for themselves. Males argued that *this is not a female issue*, but an issue affecting all engineering students. One male stressed that these types of group dynamics are typical of the *real-world environment*.

Both in classroom environments during which a professor was leading discussions and within group activities, female students felt overlooked and underestimated when they presented an idea or suggested a solution. Until a male colleague repeated the idea, it did not gain traction. The female students recognised that the males experience unconscious bias and commented that their male friends and professors are good people; however, male counterparts were blind to the differences in which men and women were treated.

There appears to be agreement from both males and females that tensions exist within group work environments; however, each has different interpretations of expectations of typical group dynamics.

## Gender

Gender differences are evident in the stereotypical approaches to technical abilities of males and females and the role models who propagate these differences. Comments about gender disparities were grouped into six categories shown in Table 1. These covered a range of students' feelings that resulted from gender differences. The sub-themes identified from these responses led to further analysis of stereotypes and the lack of role models.

**Stereotypes:** Stereotypes with respect to female roles were commonly experienced in group-work (Figure 2). Comments about group-work included issues with clashing personalities (32), communication issues (34), effort or lack thereof (94), and differing expectations (50). While these were not specifically identified as issues with gender, 16 comments directly referred to gender roles when working in groups. When provided the opportunity to comment in open-ended questions about the kinds of difficulties they have encountered within engineering, women expressed frustration with *being talked down to* by male peers or being discouraged from using workshop tools when participating in group laboratory sessions.

Table 1: Breakdown of gender related themes.

Theme	Sub-theme	Number of NVivo references (n)
Stereotypes	Condescending comments by males	26
	Historical/expected female roles	16
	Ignored	37
	Special grouping of females	5
Lack of role models	Lack of female presence	15
	Feeling undermined	29
	Sexist behaviours from professors	8

Often, *the girl jobs* refer to the non-technical tasks, including the secretarial jobs at a meeting, report editing and formatting to *make it look pretty*. Males supported these gender roles and indicated that women were naturally better at written communication than men. Students in all four years of the undergraduate programme noted these task assignments. Women believed that being assigned these tasks affected their education outcomes as they felt unwelcome to participate in the technical development of reports.

Women also identified that these issues were more prominent in *new group* situations in which they were working with male colleagues with whom they were not familiar. Some female students expressed disappointment in the *bro-culture*. They identified that their opinions were not valued even if they had significant practical field experience. The students believed that one of the reasons that stereotypical role models are propagated is the lack of female role models.

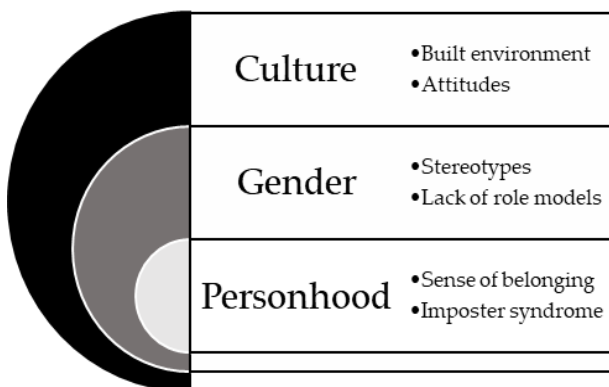


Figure 1: Themes identified through thematic analysis.

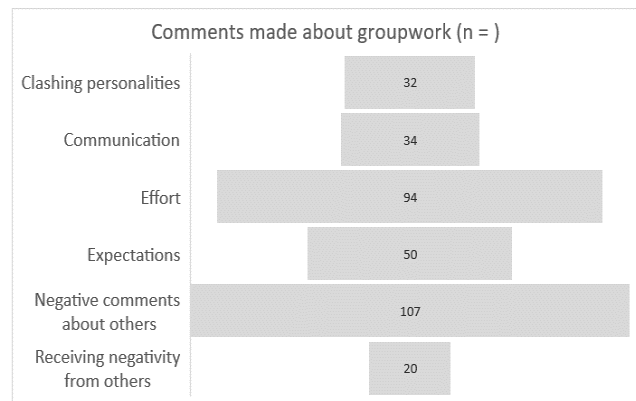


Figure 2: Breakdown of comments made by students regarding group-work.

**Lack of role models:** Professors teach and guide students throughout their education as crucial role models for students. Eighty-two comments mentioned professors of which 70% of the references were negative. From diversity to professionalism, students felt improvements could be made. Figure 3 represents the distribution of negative comments made about professors.

One survey question asked about the interaction methods with professors in a typical classroom environment. Figure 4 outlines these results. Since the number of women who took part in the survey outweighed that of men (64:36), percentages were calculated relative to the total number of students of each gender who answered the question. From this figure, approximately 35% of both males and females contact their professors by e-mail or on-line, while 35% of males and 27% preferred in-person meetings. A significant proportion of women resorted to speaking with a teaching assistant (TA) instead of the professor directly.

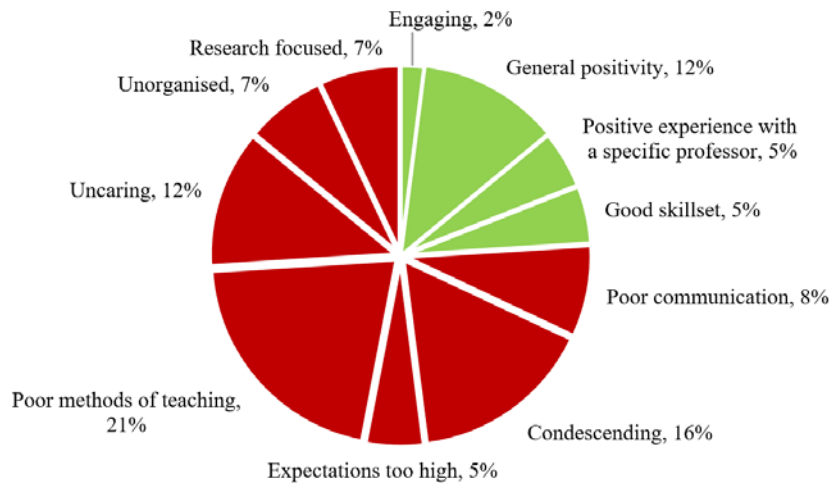


Figure 3: Weighting and overview of the 103 comments made about professors. Negative comments are displayed in black while the positive comments are displayed in grey.

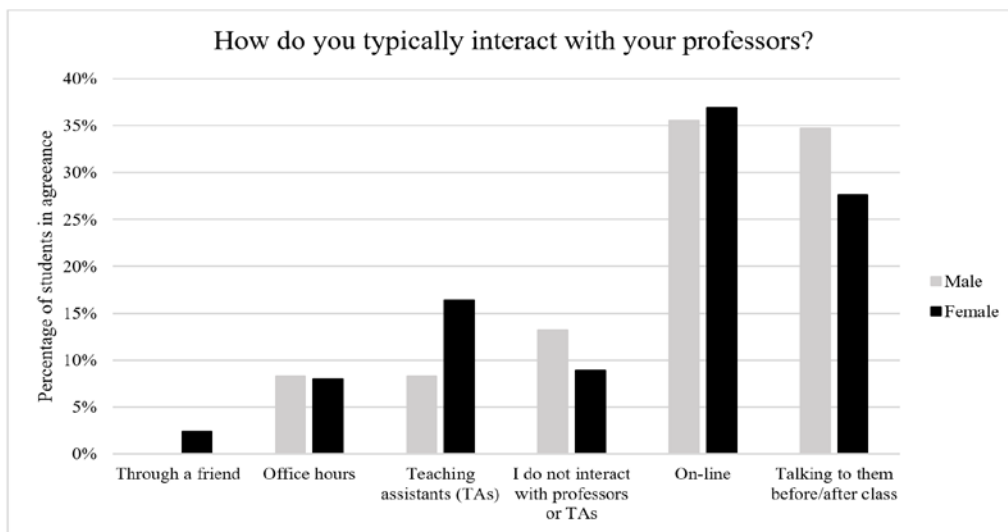


Figure 4: Methods used for interaction by students with teaching assistants and professors.

Students identified that their lack of comfort in initiating professorial interactions can be attributed to aspects relating to a lack of diversity. The students identified the need for hiring diverse professors as it is difficult to be inspired by someone *who does not represent you*. Seventy-seven percent of comments about the lack of female instructors were made by people who reported feeling discouraged in their programme. They sought mentors but felt as though the professors could not understand and advocate for them.

Female students found that male professors favoured male students by including them in gender-based jokes, while simultaneously ignoring in-class responses from female students. Sixteen stated that professors made condescending comments, of which 50% were sexist. One student was particularly frustrated by the need to show respect towards a professor when the professor talked down to her, while another indicated how educators appear to be adding barriers rather than removing them. Women were also frustrated that their male peers did not recognise that these are systemic issues that propagate into the workplace. One hundred percent of those who experienced sexist remarks from their professor also reported being discouraged in their programme. The lack of role models and the behaviour portrayed in the classroom environment can leave some female students feeling alone and discouraged.

While sexist behaviours by professors and colleagues were identified, some felt that females have advantages in the engineering profession. Three identified that women would be advantaged post-graduation by the requirement to meet diversity quotas within the industry.

#### Personhood

Of those who were comfortable speaking about their experiences, 40 delivered comments related to their mental wellbeing. These were broken down into sub-themes that included the sense of belonging and imposter syndrome.

*Sense of belonging:* The theme of being overlooked was re-introduced when asked, *What is the most frustrating part of your programme?* Of the 77 comments regarding gender, 37 comments indicated that students felt ignored by their peers, professors and the engineering community.

In 16 cases, ideas and suggestions put forward by females were not validated until a male student actively acknowledged the contribution through repetition or restated the idea as their own. One person mentioned a *group chat* in which she answered a question posed by a colleague. That same answer was repeated shortly thereafter by a male student. The initiator of the question thanked the male student while ignoring the original female respondent. A further twenty-nine comments were made by students who felt undermined by male peers. All 100% of those comments were made by participants who identified as female.

Imposter syndrome: Student comments about self-worth or personal difficulties were categorised in a mental health node of NVivo (Figure 5). Of the participants who commented, 94% also reported feeling discouraged in their programme when asked (Figure 6). Furthermore, 89% of comments about self-worth and mental health were made by persons identifying as females and 28% of the total comments made also included feeling negativity from others.

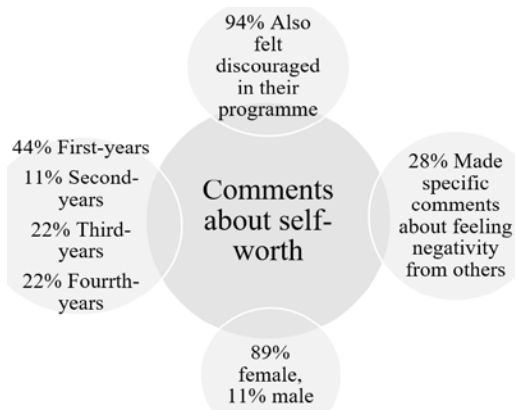


Figure 5: Characteristics of comments made by students regarding the lack of self-worth.

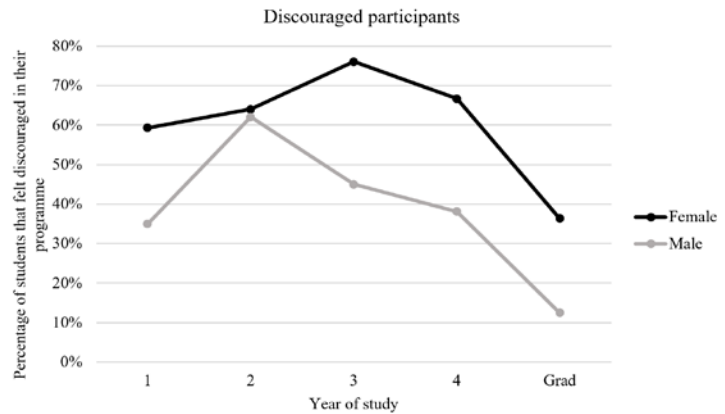


Figure 6: Comparison of the percentages of male vs. female students feeling discouraged or intimidated within their programme.

The word *imposter syndrome* was used in statements by the surveyed students. The words *stupid* and *inferior*, were also used to describe themselves alongside feelings of *not fitting in* and *not earned my place*. Some students acknowledged that their challenges included being too hard on themselves, which led to further discouragement. However, they were unable to reconcile the negative self-worth feelings with how they are treated within the profession. Some linked the lack of female representation and support to their feelings of lack of belonging.

Low self-esteem led to fear of reprisal if they asked questions in class. Female students felt personally held back in their studies due to a lack of confidence. They also felt unable to contribute equally within a team setting and were not confident in their knowledge and skill level. Comments made by female students throughout their degrees, from first year to graduate students, exemplify a trend that these feelings are common for women. When students are not comfortable in their learning environment, this ultimately affects how they learn and succeed in the programme.

## DISCUSSION

### Culture

In 2016, the university evaluated had 2,113 males enrolled in engineering full-time, and 896 females enrolled full time [10], an undergraduate female enrolment rate of 29.8%. Although the number of women students is higher than the percentage of women in engineering across Canada, women must still adapt to the predominantly male culture. This particular engineering programme is well known for its culture, traditions and sense of community. Given that almost 20% of students stated that the best part of their experience was *the community* or *the family atmosphere*, a spectrum exists that includes some who have an extremely positive experience and those with more negative exposure. The culture within the engineering programme is predominantly male-oriented. Dr Cody (after whom the Gina Cody School of Engineering and Computer Science at Concordia was named) dropped her daughter off at the university and found:

*...when women engineering students first arrive on campus, they don't always feel welcome or safe... male engineering students smacking their school leather jackets down on the sidewalk and on the road in front of cars - one of several bro culture behaviours* [11].

Also identified by Dryburgh [4], the responses from women who participated in this study showed that female students feel forced to adapt to this culture, and often have difficulty succeeding based on environmental and cultural restrictions.

Built environment: Physical barriers were identified within the university environment, suggesting a lack of equity for female students. On October 15th, 2012, a University policy was approved stating that *...the University shall ensure the existence of at least one gender-neutral washroom... on every floor of every... building* [12]. The authors' survey was undertaken in late 2019, and according to Alma Mater Society Equity services, the building previously identified as

being restrictive during an examination, has been updated to include two gender-neutral bathrooms [13]. However, as of September 2020, this particular building still had gender specific signage on the washroom doors, providing an unclear message as to whether any washrooms were indeed gender-neutral. A lack of knowledge about these modifications can lead to additional stress, especially in examination situations. Physical barriers that female students face may lead them to question their choice of study and push them away from engineering. Identifying artefacts that support the idea that women do not belong in certain spaces and addressing the associated issues appears to be an essential step in a move toward reducing barriers.

**Attitudes:** In addition to the male culture and the physical barriers to females in STEM, the authors identified that women feel alone when standing up for their rights. They are often met with dismissive attitudes from male peers and even professors, which is a well-recognised issue [14] and affects women through both schooling and industry [15]. Given that men who participated in the study argued that the difficulties experienced in group environments have *no correlation with gender* and are *very common in the real world*, the dismissive attitude is evident. A psychological study completed by Moss-Racusin et al also suggested that the female students who often perceive comments as sexist because they are the ones who most commonly experience them [5].

Over half the female students participating in the survey felt discouragement, and it can be argued based on the responses given to the open-ended questions that gender diversity has impacted their experiences and education. This result is consistent with the observations of Mazur et al, who surveyed with the same questions at another Ontario university [9]. The survey presented here has extended to graduate students whose responses also showed discouragement in 35% of the cases. The phenomenon known as the *leaky pipeline* indicates that women are less likely to be selected as graduate students in laboratories in which the principal investigator is male, which consists of 70% of the laboratories [16]. Within the Ontario environment, the proportion of graduate students in engineering is 20% [17]. Since women are more discouraged throughout their schooling, the leaky pipeline concept appears to be true.

Upon winning the Order of the White Rose, a female engineering student commented, *I learned first-hand how institutions continue to uphold systems that prioritise the well-being of perpetrators and I learned that when faced with harsh realities, many people choose to stay silent and do nothing* [18]. When males and those of authority dismiss the importance of addressing the uneven ratio of male to female engineering students, the idea that inequity stems from a systemic cultural problem is further exemplified. These behaviours lead to further implications with female students being uncomfortable advocating within group environments or lacking motivation following dismissive comments. These implications should be further researched to determine the psychological effects on female students.

## Gender

**Stereotypes:** Female students in engineering are often coerced into stereotypical roles. Further research should be conducted to explore how these stereotypes affect students' success and wellbeing. Sixteen female students spoke about being obliged to take the organisational tasks or the roles with contributing to the written component, while also being discouraged from using tools, while in a shop environment by the male group members. Constantly being left to *make things pretty* can lead to female students feeling undermined and unworthy of the technical excellence of their engineering degree. When male students reinforce the concept that women are *naturally better* at the non-technical aspects of projects, the negative stereotypes are only reinforced. Female students are restricted from learning practical skills to provide them with the best experiences within their degrees.

This research may not reflect the experience for all females in engineering, but does focus on the challenges of those who came forward about their frustrations. It is unknown whether the stereotyping has implications on the success of their degree, though in another study, Bell et al found that the negative judgements do negatively affect a student's performance [3].

The majority of comments about the typical *female role* were made by students who feel discouraged in their programme. This discouragement, along with reports from previous literature [3], suggest that stereotyping has a negative effect on the self-worth and performance of these individuals.

**Lack of role models:** Although this university has one of the highest proportions of female faculty members to male faculty members in the engineering faculty in Ontario, this percentage is still only 20% [19]. The visible lack of diversity does have an impact on students' sense of belonging and overall education. Seventy-seven percent of the females who noted the lack of female professors also identified feeling discouraged within their programme. This behaviour, also known as homophily, is recognised when students have a preference for the same gendered professor as they can better relate through similar characteristics and like-minded attitudes [20].

The students mentioned how it is difficult to be inspired by teachers when they cannot see any part of themselves. A study comparing women in engineering with different mentors [7] showed that women in engineering who did not have a direct mentor, as well as those who had a male mentor, had a steep decline in feelings of belonging and self-efficacy within engineering from the beginning to end of their undergraduate studies. However, female engineering students with female mentors maintained a positive sense of belonging and self-efficacy [7]. The study found that female

mentors bring a sense of belonging and worthiness to females in STEM and give the students more confidence within the programme [7]. Women can look up and relate to professors who are also women.

In addition to the identification of diversity issues, negative feedback was perceived (70% of 82 comments) about the professors. Students were not asked directly about their relationships with professors during the study, but the topic arose when asked what frustrates the students most about the programme. Students felt that professors do not care, are only research-focused, are condescending, and had difficulties with communication and unrealistic expectations for student workloads. It is disheartening to hear that when professors talk down to women, the female students feel they *do not mean anything*, indicating that some female students do not feel supported by the faculty.

Half the comments regarding professors' condescending remarks were perceived as sexist, and 100% of the female students who reported these comments felt discouraged within the engineering programme. When using examples of engineers in the workplace, professors tend to use strictly male pronouns. While language may not be used to exclude specifically, Stout and Dasgupta found that using gender-exclusive language is a form of ostracism and can have impacts such as feeling less included and less motivated, especially when *he* does not mean *you* [21].

Students also mentioned that some male professors do not take the women's answers seriously and are dismissive towards the women within the programme. These behaviours are dangerous as students learn and repeat actions from mentors. Hurd et al found that students often looked towards adults to determine appropriate and acceptable behaviour and modelled their actions accordingly [22]. Male students may learn from their professors and deem otherwise inappropriate behaviour acceptable, which leads to normalisation of the sexist environment even if unintentional.

When analysing the results of the question that asked how students typically interact with their professors, it became evident that women within the programme are not as comfortable interacting with the professors in person as compared to male students. All students who reported asking a friend to speak to the professors on their behalf as a preferred communication method were female students. Men were more likely to speak to the professors after class and meet the professors during office hours.

Women are more likely to reach out to the professors on-line by e-mail rather than in person and are almost twice as likely to speak with teaching assistants instead of professors compared to men. Previous literature reports that e-mail and other on-line resources are quickly becoming a preferred communication channel for students [23]. In a study focusing on communication channels and reticence, Kelly et al found reticent participants preferred asynchronous and on-line communication channels, while non-reticent participants preferred to use synchronous channels when communicating with the faculty [24]. Further research should be conducted to determine the effect of ostracism on female reticence and whether gender disparity discourages face-to-face interactions with the faculty.

## Personhood

Sense of belonging: Figure 4 shows that women are significantly more discouraged than men based on the weighted percentiles. The percentage of discouraged students for both men and women increased from the first to the second year of university. This increase could be explained by the increase in workload or because engineering students choose their specialisation upon entering second year. However, between the second year and third year, the percentage of men discouraged in their programme decreases by 17%, whereas discouragement increased by 12% for women. In the third year, 76% of all females in the survey felt discouraged in their programme, which is an alarming percentage. As the workload between genders does not differ, it can only be assumed that external factors contribute to the discouragement of women in the programme.

The authors noticed that 83% of the comments about feeling ignored and undervalued within the programme were made by female students who also reported feeling discouraged in their programme. Since the number of women who reported feeling undermined doubled between the third- and fourth-year students, it is possible that some students normalised and even accepted their feelings toward ostracism.

To be ostracised is defined as being ignored or excluded. Thirty-seven individual comments were regarding female students who felt ignored by their peers, professors and the engineering community. One student indicated that the most frustrating part of the engineering programme was that she did not feel heard, that she was continually interrupted, and after stating ideas, she was often ignored, *only to have a male teammate pitch the same idea a few minutes later and receive praise*. By definition, that student and at least 36 others were ostracised by peers and professors. Ostracism has been studied by Williams and Zadro who found that threats to the sense of belonging and self-esteem increases sadness and anger [25]. The longer and more frequent ostracism exposures require students to fortify their needs for a sense of belonging in a prosocial manner; however, when students begin to indulge in these insecurities, individuals may resort to antisocial manners. Hence, students experiencing frequent ostracism will begin to isolate themselves from the interactive aspects of the engineering programme.

Imposter syndrome: All gender-related frustrations brought up in the open-ended questions were made by female students. When female students undergo frequent gender discrimination, many experience imposter syndrome and

believe they do not belong or are not worthy of being in the programme. The ostracism that these female students endure after constantly being ignored or *looked over* impacts their sense of self-worth. Remarks, such as feeling *stupid* and *inferior* were brought up by females in the open-ended response questions and were often dismissed by comments that included *I am not sure if it is because of my gender*. With the low self-esteem associated with ostracism, female students are less likely to participate in class, such as asking questions or even engaging in group discussions. Students identified the constant use of male pronouns, which only reinforces the feeling of imposter syndrome.

As viewed by Bell et al, for students who felt ostracised, their self-confidence was impacted, and in an intellectually demanding programme as engineering, a lack of confidence and low self-esteem can affect the academic success of the students [3]. When female students find that male peers are more likely to be trusted with opinions and technical aspects of reports, imposter syndrome is confirmed, which leads to academic and personal distress, and may affect the career path of female engineering students.

## LIMITATIONS

The authors recognise that this survey and analysis have several limitations. This analysis focused primarily on gender inequity in the engineering discipline. They recognise the significance and importance of intersectionality. This research addresses only women, without accounting for other racial, socioeconomic, age, sexuality, disability, religious and cultural discrimination that the survey did not explore. Additionally, this study is at risk of confirmation bias as comments made by respondents can be misinterpreted or misunderstood by the team of all female researchers. Given the volume of comments received, addressing all the comments and concerns students expressed was challenging. Since comments were made in response to open-ended questions, some quantitative results could not be verified, though two coders independently evaluated the comments from a qualitative perspective.

Additionally, limitations in the sample include uneven distribution of participants amongst engineering disciplines. A controlled sample population amongst years, disciplines and gender would strengthen the analysis as responses were only from students willing to come forward. Students who feel content with their experiences in the programme may not have been willing to take the time to answer questions and add comments, which is a limitation to the accuracy of this study's generalisations. The results displayed by participants in this study may not accurately represent the engineering atmosphere as a whole. Finally, the potential for researcher bias exists as all authors are women in engineering.

## IMPLICATIONS FOR EDUCATIONAL PRACTICE

With the small number of females graduating from engineering programmes, it is clear that there are areas for improvement. Universities and staff must work together to issue a systematic institutional change and create an inclusive and welcoming culture for all. Professors should work with students to receive feedback on facilitating their learning through anonymous surveys, office hours or open discussions. Students need a safe space where they can participate without fear of judgement or discrimination. It is also recommended that staff undertake professional development to be inclusive in the way they teach. Gender pronouns do not need to be featured in lecture questions or examples.

More female professors and teaching assistants should be hired to improve the support for female students and provide them with role models. Increasing the awareness or number of female mentorship programmes would also be beneficial. Many students felt that they did not have role models, which suggests a lack of outreach for existing programmes or resources available to these students. It is important to continue holding events that empower women in STEM to help students feel heard, visible, and to help motivate them through these challenging times.

Engineering has traditionally been a male-dominated field with a heavily male culture; thus, further research should be encouraged to make the environment more inclusive to women. Studies and surveys should be continued to understand this culture's effect on female students. This study suggests that the *bro-culture* leads to discouragement, a lack of confidence, and a lack of sense of belonging, with no conclusive findings of its effect on academic success. It is a greater systemic problem and changes must start from the institutional level.

## CONCLUSIONS

It is evident that the engineering culture continues to create barriers both physical and attitudinal that must be addressed to enable equal access and equity within the programme. Gender stereotypes are propagated within the academic environment through the use of male pronouns and sexist jokes, while there are few female role models to act as mentors to women students. On a personal level, women lack the sense of belonging, feeling ostracised within the engineering environment which leads to feelings of imposter syndrome.

University administration must identify these barriers within their own engineering faculties and seek to address the concerns of women students. The educational setting is the environment in which students learn from their mentors and professors. By addressing the systemic barriers at the university level, acceptance to STEM and the workforce by women in engineering has the potential to be greatly improved. This research emphasises the importance of diversity, equity, and inclusion in the field of engineering and suggests the psychological effects of the lack thereof. Implementing



equitable practices into the field of engineering including education, research, reflection, and re-building the patriarchal faculty has the ability to break down barriers to allow women and those of all minorities to succeed in this field. People must re-establish how they think of a *typical* engineer and work towards creating a safe, welcoming and inclusive environment for all.

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## REFERENCES

1. Corporate Planning and Policy Division, NSERC: Women in Science and Engineering in Canada (2017), 2 June 2022, [https://www.nserc-crsng.gc.ca/\\_doc/Reports-Rapports/WISE2017\\_e.pdf](https://www.nserc-crsng.gc.ca/_doc/Reports-Rapports/WISE2017_e.pdf)
2. Singh, R., Zhang, Y., Wan, M. and Fouad, N.A., Why do women engineers leave the engineering profession? The roles of work - family conflict, occupational commitment, and perceived organizational support. *Human Resource Manage.*, 57, 4, 901-914 (2018).
3. Bell, A.E., Spencer, S.J., Iserman, E. and Logel, C.E.R., Stereotype threat and women's performance in engineering. *J. of Engng. Educ.*, 92, 4, 307-312 (2003).
4. Dryburgh, H., Work hard, play hard: women and professionalization in engineering - adapting to the culture. *Gender & Society*, 13, 5, 664-682 (1999).
5. Moss-Racusin, C.A., Molenda, A.K. and Cramer, C.R., Can evidence impact attitudes? Public reactions to evidence of gender bias in STEM fields. *Psychology of Women Quarterly*, 39, 2, 194-209 (2015).
6. Thompson, M.J., Carlson, D.S., Kacmar, K.M. and Vogel, R.M., The cost of being ignored: emotional exhaustion in the work and family domains. *J. of Applied Psychology*, 105, 2, 186-195 (2020).
7. Dennehy, T.C. and Dasgupta, N., Female peer mentors early in college increase women's positive academic experiences and retention in engineering. *Proc. National Academy of Sciences*, 114, 23, 5964-5969 (2017).
8. Mazur, N., Chorlton, B. and Gales, J., Comparing the experiences of women in undergraduate engineering across different schools. *Canadian Engng. Educ. Assoc. Conf.* (2019).
9. Mazur, N., Chorlton, B. and Gales, J., The experiences of women in undergraduate engineering. *Canadian Engng. Educ. Assoc.* (2018).
10. Queen's University, Common University Data Ontario (CUDO), (2017), 2 June 2022, <https://www.queensu.ca/planningandbudget/sites/webpublish.queensu.ca.pbwww/files/files/IRP/Queens%20CUDO%202017%20FINAL.pdf>
11. Peters, D., The engineering gender gap: it's more than a numbers game. *University Affairs* (2020), 2 June 2022, <https://www.universityaffairs.ca/features/feature-article/the-engineering-gender-gap-its-more-than-a-numbers-game/>
12. Queen's University, Gender Neutral Washrooms Policy, 2 June 2022, <https://www.queensu.ca/secretariat/policies/administration-and-operations/gender-neutral-washrooms-policy#C>
13. Alma Mater Society Social Issues Commission, Orientation Roundtable: Gender Neutral Bathrooms Master List (2021), 07 June 2022, <http://www.qcomputingorientation.ca/2021-ORT-Handbook.pdf#page=16>
14. Pultarova, T., *If you stand up for yourself, it backfires* - female engineers on careers in a man's world, 3 December 2020, <https://www.imeche.org/news/news-article/feature-'if-you-stand-up-for-yourself-it-backfires'-female-engineers-on-careers-in-a-man's-world>
15. Fouad, N.A., Chang, W.-H., Wan, M. and Singh, R., Women's reasons for leaving the engineering field. *Frontiers in Psychology*, 8, 875-875 (2017).
16. Grogan, K.E., How the entire scientific community can confront gender bias in the workplace. *Nature Ecology & Evolution*, 3, 1, 3-6 (2019).
17. Wells, M., Closing the engineering gender gap. *Design Engineering*, 3 December 2020, <https://www.design-engineering.com/features/engineering-gender-gap/>.
18. Foley, J., Local student awarded Order of the White Rose scholarship. *Kingstonist*, ed. Kingston (2020).
19. Streisfield, E., The hidden gender disparity in ECE. Queens University, *The Journal* (2016), 2 June 2022, <https://www.queensjournal.ca/story/2016-10-05/features/the-hidden-gender-disparity-in-ece/>
20. Brechwald, W.A. and Prinstein, M.J., Beyond homophily: a decade of advances in understanding peer influence processes. *J. of Research Adolesc.*, 21, 1, 166-179 (2011).
21. Stout, J. and Dasgupta, N., When he doesn't mean you: gender-exclusive language as ostracism. *Personality & Social Psychology Bulletin*, 37, 757-69 (2011).
22. Hurd, N.M., Zimmerman, M.A. and Xue, Y., Negative adult influences and the protective effects of role models: a study with urban adolescents. *J. of Youth Adolesc.*, 38, 6, 777-789 (2009).
23. Huang, S.C., Chen, C.-H. and Chen, H.-I., A case study of communication channels in a graduate program. *Proc. American Society for Infor. Science and Technol.*, 41, 147-155 (2005).
24. Kelly, L., Keaten, J.A. and Finch, C., Reticent and non-reticent college students' preferred communication channels for interacting with faculty. *Commun. Research Reports*, 21, 2, 197-209 (2004).
25. Williams, K.D. and Zadro, L., *Ostracism: the Indiscriminate Early Detection System*. The Social Outcast: Ostracism, Social Exclusion, Rejection, and Bullying. Sydney Symp. of Social Psychology Series. New York, NY, USA: Psychology Press, 19-34 (2005).

## BIOGRAPHIES



Sydney van Engelen is a current Master's student of applied science in collaborative biomedical engineering studying at Queen's University in Kingston, Ontario. She graduated from Queen's University with a Bachelor's degree in mechanical engineering with a specialisation in biomechanical engineering. Sydney is enrolled in the interdisciplinary Research and Education in Accessibility, Design, and Innovation (READi) training programme at Carleton University to develop an accessibility mind-set in innovation and design to support a more inclusive society. During her undergrad, Sydney worked in the Building and Designing Assistive Technology (BDAT) Lab at Queen's University studying both assistive technology, as well as the experiences of female engineering students.



Jillian Henderson graduated from the biomechanical engineering programme at Queen's University, where she is now completing a Master's in mechanical and materials engineering with a specialisation in collaborative biomedical engineering. The focus of her research is aiding in the creation of the standards for the Accessible Canada Act, primarily working with individuals who use augmentative and alternative communication (AAC) devices. Alongside aiming to make assistive technology more accessible through developing a database containing the AAC device available in Canada, alongside how and where you can gain access to the devices; Jillian volunteers as a mentor and guide to female students entering the engineering programme at Queen's University, providing resources and support.



Deena Salem is an Educational Developer at the Centre for Teaching and Learning at the University of Regina. Dr Salem is an engineer by training; her engineering research focused on microwave planar structures. She intertwined her disciplinary research with teaching and learning research and projects; enabling her to contribute to multiple education projects, including active learning instruction in STEM courses, initialisation of a community of practice of engineering instructors to share their experiences and interventions in engineering education, supporting faculty development and designing professional development programmes for teaching assistants in multiple higher education institutions.



Claire Davies is an Associate Professor in the Department of Mechanical and Materials Engineering at Queen's University. The primary focus of Dr Davies' research is increasing independence for individuals with disabilities. Her research involves evaluating strategies for upper limb and lower limb motor control, developing a model of cognitive, perception, and motor control strategies from data gathered from persons with disabilities and evidence based universal design of AT. Dr Davies's expertise of the psychological and perceptual aspects of the senses, primarily vision, haptics and sound is used in the design and creation of human machine interfaces that are easily navigated and accepted by children with motor disabilities with little or no functional speech to control their interactions with peers.