Fostering Educational Equity in Engineering

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Abstract: This is a research paper. Students in introductory engineering courses face challenges communicating and integrating their ideas in team projects. Often these challenges with team communication fall along gendered lines, where women students experience marginalization in team settings. While these issues can, and have been, attributed to implicit gendered communication practices and explicit ideological bias, this research seeks to identify concrete ways in which educators might intervene to create more inclusive learning environments. This research integrates frameworks from the domains of engineering education and technical and professional communication. Researchers in engineering education have evaluated the ways in which the curriculum can be altered to be more inclusive and assessed the outcomes of diverse teams in the classroom. In technical and professional communication, researchers have developed taxonomies for understanding how marginalization and inclusion in communication operates both at the level of students and teachers, but also through physical classroom settings and the larger educational context. However, there is still a need for further research to create more equitable STEM classrooms. To that end, our study seeks to gain firsthand insight from women and gender-diverse students and faculty members regarding their experiences in academia. Participants share perspectives and strategies for overcoming experiences of marginalization and creating more welcoming and inclusive learning environments in introductory engineering courses. This qualitative study seeks to answer the following questions: (1) What types of marginalization do women students experience while communicating their work in introductory engineering courses?; (2) What strategies do they currently use to circumvent that marginalization?; and (3) What strategies might instructors implement to assist women students in circumventing these moments more effectively? Grounded in an intersectional feminist theoretical orientation, this research includes semi-structured interviews conducted with a critical incident data collection method. We interviewed students and faculty about their experiences with communication challenges. Our analysis reveals how woman and gender diverse students experience marginalization, as well as faculty perceptions of these classroom experiences. This study provides insight into how institutions can enhance classroom interaction to benefit diverse groups. More specifically, this research offers the opportunity for expansion and inclusion within STEM fields.

Keywords: Intersectional feminism, infrastructural rhetoric, gender equity, communication and teamwork.

1. Introduction

“I don’t know; I guess we’ll just need to talk it out a bit more as a team.” These sentiments came up frequently in conversations with introductory engineering students at the center of this study on fostering educational equity in engineering. Our research participants, many brilliant, capable women engineers, described their difficulty collaborating and communicating with teams in their engineering projects, because they are not seen or treated as equals in educational engineering settings. For a variety of reasons, they are often sidelined or ignored. In extreme cases, our participants experienced instances of outright discrimination or marginalization. However, while our study and the scholarly literature is filled with examples of gender bias and marginalization in engineering education, the field lacks concrete solutions, and those in most need of assistance often feel powerless to enact change. When asked how they might resolve such issues, our participants (students and professors alike) returned generalities. Communication

is important, they agreed, but communication can be a vexing process that often returns just as much inequity as inaction. More is needed than simply "Talking it out." This claim shapes our present paper.

Inequities push marginalized students to do "menial tasks" (Silbey, 2016) blocking them from substantially contributing to the technical aspects of the project (Cardador & Caza, 2018). In collaborative settings, the confluence of identities which shape an individual impacts how the individual is perceived by others (Ro & Loya, 2015). If not carefully structured and cared for by a competent faculty member, this results in a disparate team experience (Mallette, 2022). The challenge then becomes on the faculty to define and deliver an authentic experience that values diverse team settings and leads to impactful and meaningful experience for all students (Borrego et al., 2013).

Too often marginalized individuals are told to talk it out or communicate more without instruction on how to do so or systematic support to have such conversations. In the worst cases, these individuals are simply told to "deal with it" or that such instances of discrimination will "help prepare them for the workforce" (Beddoes & Panther, 2017). It is highly problematic to expect marginalized individuals to fix their own marginalization while pursuing their education. To do so is to ask them to take on a double workload compared to their unmarginalized peers. As such, it is no wonder that the attrition rates are so high amongst those who are marginalized (Rincon, 2018; Roy, 2019), as "adapt or flee" remains the current expectation in engineering.

Issues of marginalization are compounded by generalized communication practices and advice. When teams are told to communicate more with members, but active steps are not taken to resolve issues of marginalization, the communication practiced only results in further marginalization. It is necessary therefore to not only seek to change the communicative practices that create or compound students' experiences of marginalization, but to analyze and change the infrastructures that facilitate marginalization in the first place. Our current research project seeks to address this critical need. However, studying marginalization and creating conditions for change requires a new methodological approach to engineering communication. This paper proposes a new integrated methodological approach to systematically analyzing communication infrastructure with the goal of offering evidence-based practices for countering marginalization in engineering communication practice and research.

2. Literature review and identified gap

As a profession, engineering is dominated by teamwork. In academic contexts, engineering educators attempt to provide meaningful teamwork experiences for students to prepare them for the profession. The emphasis on teamwork as a learning outcome has recently increased (ABET, 2012; Patil & Codner, 2007), with team projects spanning the entire engineering curriculum from first-year courses to capstone courses (Froyd, 2005). As a learning outcome, teaming is linked to a wide range of professional skills, including communication, ethics and lifelong learning (Borrego et al., 2013). In academic contexts, students are expected to simultaneously acquire a combination of skills while trying to effectively contribute to the project with their peers. In engineering education literature, learning in teams is sometimes referred to as project-based learning (e.g., Marquez et al., 2011) and collaborative learning (e.g., Gunderson & Moore, 2008). Literature on learning styles also characterizes the different behaviors of student learning that take place in a team setting (e.g., Bermejo et al., 2011).

In their systematic review of the literature, Borrego et al. (2013) conceptualized teamwork along five models of effectiveness: social lofting, interdependence, conflict, trust, and shared mental models. In our work, we are interested in effective communication as a learning outcome through team projects.

Communication facilitates all other learning outcomes in an effective team setting; communication represents the primary mode of interaction to develop shared mental models (Edwards et al., 2006), to cultivate trust (Webber, 2008) and to resolve conflicts (Worthen, 2004). Research on the topic differentiates between self-managed teams; that is, those who are empowered to pursue tasks independently (Kozlowski & Ilgen, 2006), and guided teams; that is, those who follow an established hierarchal structure in performing their tasks (McNair et al., 2011). The degree to which engineering educators are willing to enable teams to independently develop their identity in performing the task tends to shape the communication patterns that take place among student team members (Sheppard, Dominick, & Aronson, 2004). While engineering educators share strong values in preparing students for teamwork, they show different behaviors in how they achieve this as a learning outcome. Improving team effectiveness is a complex topic as it requires engineering educators to understand team dynamics (Douglas-Mankin, 2008), learning styles (Fiegel & Denatale, 2011), and teamwork assessment (Davis et al., 2010). Because communication among team members directly affects team performance and effectiveness, engineering educators must both facilitate and assess communication between students.

Research suggests that feedback loops between students and the educator are key to capturing, facilitating, and assessing complex team dynamics (Mathieu et al., 2008). especially as time progresses and team members start to develop skills to mediate conflicts and align goals (Kozlowski & Ilgen, 2006). As more feedback is received from students, however, the role of the educator is not clear (McGourty et al., 2002; Shuman, Besterfield-Sacre, & McGourty, 2005). Should the educator intervene in resolving conflicts? Or should the educator maintain a hands-off approach? When should the educator intervene, and in what ways? In our work, we explore how communication can be used to facilitate and address teamwork issues. We are specifically interested in how women and gender-diverse students often experience marginalization when working in teams. These experiences of marginalization for some students act as another barrier for the team's ability to understand and agree upon goals (Mathieu et al., 2008). Marginalization in student teamwork limits the utilization of resources available within the team's repertoire, raises issues of trust and conflict, and causes conflict due to roles assignment and shared leadership (Yang and Yan, 2002). While clearly defining goals for the team seems to be the easiest task on the part of the engineering educator, providing a safe environment for effective communication within diverse teams, along with accountable interdependence, is a more sophisticated task. This task requires the engineering educator to master a new set of tools and strategies to facilitate communication within diverse teams of students.

2.1 Identified gap

Our work here begins with the acknowledgement of the prevailing gender gap within the engineering classroom (Lord et al., 2009; Ohland et al., 2008). Students identifying as women, especially women of color, often face both explicit and subtle forms of bias undergirding their educational experiences (Lee, 2020; Potvin et al., 2018; Ross et al., 2020). This marginalization in engineering education is problematic as inequities at the level of education carry over into industry (Campero, 2021), perpetuating the cycle of marginalization and promoting the acceptance of curricular statements such as "by not paying attention to gender when forming teams, they were helping to prepare students for the workplace" (Beddoes & Panther, 2017). Preparation, in this case, means extending students' experience of consistent and inequal treatment by colleagues from industry to the classroom.

Some studies attempt to soften the impact of these claims by placing the responsibility of dealing with discrimination and marginalization on the marginalized. These studies have evaluated how women have the desire to help others, driving their chosen discipline within STEM, but this defense justifies the inequities and circumvents any hope of progress (e.g., Potvin et al., 2018). Many engineering education researchers and educators believe that such a stance is unacceptable, arguing for the need for more

inclusive and responsive pedagogies (Beddoes & Panther, 2017). While minoritized students falling into managerial or secretarial roles in a teamwork environment appears driven by a desire to help, this argument relies on the normalization of ideological roles that stem from the marginalization in the first place (Lee, 2020). We do not take up this self-reifying discussion. For educators, the first step to enacting change and creating an inclusive environment that promotes positive outcomes for all students is acknowledging that minoritized students face challenges that their non-minoritized peers do not. Their experiences inside and outside of the classroom are different because of their minoritized status; a lack of acknowledgement only perpetuates this reality. This acknowledgement, however, leaves us with an interesting problem. Who is the marginalized group and how might we identify them? For this we turn to the interdisciplinary field of technical communication, which has been defining these issues at length for some time (Walton, Moore, & Jones, 2019; Rea, 2022).

This qualitative study seeks to answer the following questions: (1) What types of marginalization do women students experience while communicating their work in introductory engineering courses?; (2) What strategies do they currently use to circumvent that marginalization?; and (3) What strategies might instructors implement to assist women students in circumventing these moments more effectively? The third research question is both a research question and an implication at the same time, as the answer to which is shaped by both participants' own recommendations and our research findings.

We focus on the first-year engineering experience as the building foundation for students where they are expected to behave in a team experience for the first time and deliver a professional project. In the first-year engineering experience, students are exposed to teamwork for the first time in the engineering curriculum, which makes the context ideal for answering our research questions.

3. Conceptual framework

Our study takes up the exigence to foster more equitable learning experiences for marginalized and minoritized students. However, in order to do so, we must both establish what how we understand who constitutes marginalized students and provide a methodology to work toward a solution. In the following sections, we draw on two key interdisciplinary theoretical frameworks used in technical writing: intersectional feminism and infrastructural rhetoric.

3.1 Intersectional Feminism

Kimberlé Williams Crenshaw theorized intersectionality to understand how interlocking systems of oppression affect marginalized individuals in a variety of ways dependent on their positionality (Crenshaw, 1989). Simply put, intersectionality is the theory that an individual's marginalized status is not related to a singular aspect of their identity. The marginalization brought about through gender in an engineering program, for example, may be compounded (or "intersected") with an individual's race, sexual orientation, or socioeconomic condition. Taking an intersectional approach is especially vital for feminist educational research, as too often such interventions solely emphasize the experiences of privileged white women. For example, Kimberly A. Scott and Patricia Garcia (2016) found that women of color were often left out of feminist research on equity in STEM. Jones, Moore, and Walton (2016) argue it is vital to center perspectives of marginalized technical communicators in order to reshape the discipline and industry of technical and professional communication. Following their call, our research starts with the lived experiences of minoritized and marginalized educators and students working to transform engineering education, understanding that marginalization in the classroom is not only influenced by gender, but also other many-faceted aspects of identity. Only through an intersectional

feminist conceptual framework can we create a meaningful intervention into marginalization in the engineering classroom.

3.2 Infrastructural Rhetoric

While intersectional feminism informs whose voices we intentionally center in our research and our reflective research methods, we introduce infrastructural rhetoric to make these interlocking systems of privilege and inequity *visible in a way that invites intervention through communication*. Having made the connections between the endemic issues of inequity in engineering and our intersectional methodology, we next look for ways to enact changes in communication settings in STEM education. Our primary method of doing so comes from the field of rhetoric.

Rhetoric is the study of persuasion. Practitioners of rhetoric focus on looking at how individuals in a variety of settings communicate with one another to accomplish shared tasks. While we may frequently associate the term rhetoric with its more exaggerated uses, like bombastic rhetoric on the nightly news or a political candidate referring to their rival's promises as "mere rhetoric," the term and study applies to almost every communicative act. Rhetoric exists in our daily conversations and in the political sphere as much as it exists in engineering teams. Our present research is concerned with the field of technical communication, which draws heavily upon studies in rhetoric to describe and understand how we communicate in technical settings, especially in the engineering teams in the classroom.

However, while studying communication and persuasion between a communicator and audience is a broadly effective practice taught across universities globally (Jose, 2016), knowing when and how to enact effective communication practice can be difficult without knowing the surrounding factors that influence communicative success. Too often, communication advice, when scrutinized, boils down to a variation of, 'have more moments of communicative interaction' (see Beddoes & Panther, 2017, for example). Such practices in marginalized settings, however, if lacking care, risk ignoring communicator's intersectional identities and promoting a marginalizing status quo. More conversations through an approach blind to participants' experiences of marginalization will simply beget more marginalization.

To prevent these ends, we conceptualize this research through the contemporary theory of infrastructural rhetoric (Adams, 2022). This theory postulates that understanding the surrounding human-created forces, which are present in broad communicative settings, makes unforeseen communicative challenges and marginalization visible to the researchers. More importantly, the theory advocates that such communicative challenges can be rendered avoidable and persuasively malleable with close observation and research.

3.3 Conceptual framework synthesis

We integrate intersectional feminism, which explores the compounded, intersecting, and interlocking systems of privilege and inequity, with infrastructural rhetoric, which aims to make visible elements that invites intervention through communication. In our integration, we view all infrastructures that we experience (e.g., our buildings, finances, ideological beliefs, etc.) as the result of humans coming together at various moments and communicating with one another. During these moments of communication, these infrastructures are created with certain purposes in mind by their creators. When these purposes no longer suit the current users, the infrastructures can be repurposed through careful further communicative action. Knowing how to begin this careful communicative repurposing involves trying to understand the inter-related complexity of the infrastructures that surround a traditional communication activity (e.g., working on a team project in an engineering classroom), and then determining the level of difficulty involved in changing one of the infrastructural factors. As a starting point for the analysis, Adams (2022)

provides a taxonomy of common infrastructural categories and a method of mapping out various infrastructural factors that have an impact on communication. These initial taxonomic categories are summarized in Table 1.

Table 1: Infrastructural Rhetoric Taxonomic Categories

Taxonomic Category	Description
Social	The longstanding relationships, values, and ideals that people bring into a communicative exchange.
Physical	The structural and molecular environment that the communicative practice is situated in and throughout.
Economic	The financial and fiduciary realities that affect communicative practice.
Authority	The structures of command and power that impact communication
Operational	The repeated responsibilities and tasks that shift the nature of communication.

Adams (2022) begins with these categories and then invites a mapping of the infrastructure surrounding the communicative activity in question to determine which actions within the infrastructure are easiest to achieve. Keying into these taxonomized factors and their relation to communication allows us to target specific, meaningful interventions in the engineering classroom. Infrastructural rhetoric makes broader infrastructural factors visible in a way that facilitates change, offering a clear way to intervene in educational experiences of marginalization. To date, this theoretical approach has yet to be applied in educational settings in STEM, but its implementation may provide a firm grounding for meaningful changes in both instructor and student communication practices to prevent marginalization.

While more scholarship is coalescing around the experiences of students with multiply marginalized identities in technical writing and rhetoric, (see Vakil, 2018), Mallette (2022) argued, “few studies focus on the intersectional experiences of STEM participants” (p. 7) . To address this gap, we synthesize our conceptual framework to address perceived issues in the local communication context of these individuals, attitude challenges, and systemic problems documented in scholarly literature. As infrastructural rhetorical studies need to locate themselves around a series of centralizing repeated rhetorical exchanges, this study has selected those that occur within the introductory engineering classroom. Introductory engineering programming courses are widely understood by students to function as a gatekeeping mechanism for would-be future engineers, making them critical sites for marginalized exclusion. As Lizzy, a first-year aerospace engineering student and study participant, described, “We do have something called the gauntlet for a reason. Engineering is not for everyone.” When the marginalized students experience communication challenges, these are often discounted. To prevent these outcomes our present study conducts a series of interviews to get a better understanding of the infrastructure surrounding these gatekeeping courses in the hopes of improving the communicative practices within them.

4. Research method

4.1 Context of the study

This study takes place in a relatively small, engineering-focused college located in the Southwest. In this study, we are focusing on settings where technical communication takes place in student team projects, as opposed to coordination that takes place virtually over a network of computer systems. In such settings,

the process of communication becomes dominated by a number of contextual factors within the instructor's control that can affect the marginalization of students. The physical layout of classrooms, team leadership, and the introduction of preliminary background knowledge might all affect the communication practices of students. In such a context, heightened communication challenges exist for minoritized and marginalized students. In a study by Borrego et al. (2013), a systematic review of 104 articles, published between 2007 and 2012 on engineering and computer science student team projects, 30 papers identified communication skills as essential learning outcomes in the team setting. Therefore, the context of this study is chosen to explore specific strategies for educators to facilitate engineering student teamwork by focusing on technical communication and rhetorical exchanges between them. We do not consider virtual team settings in contextualizing this study.

4.2 Data collection: Participants and recruitment

The study utilizes interviews as the data collection method. Data was collected through interviewing student participants and faculty participants as detailed below.

Student participants

The main participants are students from the introduction to engineering class. The research team reached out to the entire population of students in that class. In this class, ideally, there are 9 to 10 sections, with about 40 students in each section. Students participate in up to 10 collaborative teams guided by the faculty. For the purposes of this study, a total number of 13 women students were recruited to participate in the interviews. Only individuals who are 18 years or older were asked to participate in this study.

Recruitment of student participants

Recruitment was conducted by three of the researchers: one who is an instructor-of-record for three of the sections of the course, another is a researcher who is not involved in teaching the course, and a third is an undergraduate student researcher with the research team who has previously completed the course. Students were recruited in all the sections of the course during Fall 2022. After potential participants suitable for the purpose of this study were identified, they were invited via email to participate in an interview.

Faculty participants

Faculty participants for this study include individuals who are involved in developing and teaching the same introductory engineering class from which student participants were recruited. In addition, other faculty were recruited who were not directly involved with the course but who taught other courses for which the introductory engineering class is a pre-requisite. Recruiting faculty participants from this population will be important in triangulating the students' experience with the faculty experience. For the purposes of this study, 6 faculty were recruited to participate in the interviews.

Recruitment of faculty participants

The research team in this study worked through the introductory engineering course coordinators to invite faculty to participate, in addition to reaching out to faculty directly. Faculty participants were recruited in Fall 2022 via email.

4.3 Data collection: Interviewing process

Student participants:

Participation in this study was voluntary. Student participants were asked to be interviewed by the research team. During the interviews, detailed questions about communication experiences and behaviors in diverse teams were asked. Interviews were audio recorded and transcribed. In general, the interviews did not last more than an hour. Data was collected over the course of one semester during Fall 2022.

Faculty participants:

Participation in this study was voluntary. Faculty participants were asked to be interviewed by the research team. During the interview, questions were asked to determine the extent of the faculty's engagement with student communication experiences and behaviors in their classrooms. The interviews were designed to help in identifying enablers and barriers to making changes in the classrooms, especially in diverse team settings. In addition, the interviews with all faculty were designed to be used to determine the baseline of teaching practices throughout the course.

4.4 Interview protocol development

The interviews of both student and faculty participants utilized the critical incident review data collection method (Flanagan, 1954; McClelland, 1973; Walther, et al., 2009; Walther & Radcliffe, 2007) to connect faculty involvement in the classroom with students' reported experiences and behaviors. The interviews started with questions to elicit concrete, critical incidents related to communication challenges (in the case of the student participants) and related to dealing with communication issues within teams (in the case of faculty participants).

For example, for the student participants, the interviews started by asking questions such as, "Can you describe a moment when you faced a communication challenge due to your gender/age/cultural identity in the classroom?", "How did you feel about this incident?", and "What did you do to navigate this situation?". For the faculty participants, the interviews were designed to elicit concrete, critical incidents about dealing with communication issues within teams. For examples, interviews started by asking questions such as "Think about a class that you recently taught, could you select one day and describe that class in detail?", "How did you prepare for effective students' communication for this class?", "Did you get frustrated with students at all during this class?", and "Were you excited during this class about progress that you made?".

After exploring these near-experience incidents with participants, the interview protocol progressed to explore a distant-experience to help understanding of the role of communication, teamwork and issues of marginalization (Geertz, 1974). Additional questions were included to assess participants' role as engineering learners and educators as well as their understanding of the importance of communication in diverse engineering teams.

Table 2 below shows the overall structure of the interview protocol for both student and faculty participants. The table also shows the relationship between the questions asked for each group in order to substantiate evidence of similarities and differences between the two groups, as well as links between the interview questions and the research questions.

5. Plans for data analysis

We have concluded the data collection for this research and are currently in the process of analyzing the interview data. This qualitative study will use coding practices derived from grounded theory (Saldaña, 2016). After segmenting the data, we will use theoretical coding, emotion coding, and values coding to better understand the complex communication experiences of students and faculty. Because of the nature of the interview protocol, it is important in our early efforts of analysis to understand the data structure.

Our interview protocol has three major segments: the critical incident reviews; characterizing issues of marginalization and strategies to navigating them; and characterizing issues of infrastructure rhetoric. We strategically designed the protocol to allow comparisons within cases (i.e., students-students and faculty-faculty) and across cases (i.e., students-faculty). This research design allows richness in the data analysis and to understand the research questions. We are in the process of analyzing the interviews in a way that allows the multiple cases to be explored. Specifically, the variations in participants' responses is purposefully enabling comparisons to be made, within and across cases. We are interested in highlighting the gap between the students' experiences and the faculty experiences.

The relatively large data size, the variations in participants' experiences (as illustrated in their reported critical incidents), and the emergent nature of the participants' suggested strategies to deal with marginalization and the infrastructure rhetoric are enabling us to capture fine details for how to foster equity in engineering education. We are iteratively arriving to recommendations for future interventions. Overall, our systematic process of coding and formalizing the code book allows us to organize the data in different ways around the research questions, which is a unique process for moving the qualitative findings into practical implementations.

6. Preliminary findings

While our data analysis is ongoing, we share several narratives from our student and faculty research participants here to gesture toward insights into the rhetorical infrastructural of the engineering classroom. In so doing, we hope to shed light on students' experiences and faculty perceptions of marginalization in introductory engineering classrooms. This article shares stories from three student participants: Mercedes, Lizzy, and Raina. Mercedes is a first-year aerospace engineering major who identifies as a Mixed (African American and Caucasian) woman. Lizzy is a first-year aerospace engineering major who identifies as a white woman and as a person with a disability. Finally, Raina is a first-year mechanical engineering major who identifies as Hispanic and female and nonbinary. All three participants described identity-related communication challenges and moments of marginalization at different points in their coding classes.

For Mercedes, the social, authority, and physical components of the rhetorical infrastructure proved most salient to her experience of marginalization. She described a situation where her ideas and contributions were consistently ignored by the two male engineering students on her team. In her team of four, one male student self-selected as the team lead, with the other male student taking up the design role. The team lead directed Mercedes to take up the "notetaker role" even though she had an equal amount of previous engineering design experience. The final member of the team, another woman, decided to take on the coding position.

Table 2. Overall structure of the interview protocol for both student and faculty participants.

Research question	Student participants	Faculty participants
(1) What types of marginalization do women students experience while communicating their work in introductory engineering courses?	1. Can you describe a moment when you faced a communication challenge due to your gender/age/cultural identity in the classroom?	1. Can you describe a moment when you found a student facing a communication challenge due to their gender/age/cultural identity in the classroom?
(2) What strategies do they currently use to circumvent that marginalization?	… What did you do to navigate this situation?	… What did you do to navigate this situation?
(3) What strategies might instructors implement to assist women students in circumventing these moments more effectively?	2. How might instructors work to better remedy situations like these?	2. How might instructors work to better remedy situations like these?
(3) What strategies might instructors implement to assist women students in circumventing these moments more effectively?	3. How might instructors work to prevent situations like this in the first place?	3. How might instructors work to prevent situations like this in the first place?
(1) What types of marginalization do women students experience while communicating their work in introductory engineering courses?	4. In the incident you just described to me, do you think you were marginalized?	4. In the incident you just described to me, do you think the student was marginalized?
(2) What strategies do they currently use to circumvent that marginalization?	What strategies do you use to circumvent marginalization?	What strategies do you use to circumvent marginalization?
Infrastructure: Physical	§ How were you seated in the classroom?	§ How were students seated in your classroom?
Infrastructure: Authority	§ Who was the leader of your team?	§ Did you assign leaders for teams or let students select their leaders?
Infrastructure: Economic	§ Do you have a job outside of school?	§ Do your students have jobs outside of school?
Infrastructure: Social	§ How would you describe yourself as a student?	§ Can you describe some general difficulties that you have with students in the classroom?
Infrastructure: Operational	§ What kind of training were you given prior to working on your team project?	§ How did you prepare for effective student communication for this class?

Mercedes explained how the team lead's communication strategies, including a practice of saying, "I hear you, but I'm not going to listen to your idea," functioned to effectively exclude her from the design process. Only when the first ideas failed and Mercedes' original suggestions were echoed (without attribution) by the second male student, did the team lead try them. This social dynamic led to frustration on the part of the women students–the coding student would frequently get discouraged and leave the class early. However, despite drafting a clear written process for negotiating change and authority, this process was ignored when the students became stressed about the assignment deadlines.

Unfortunately, Mercedes felt that she couldn't appeal to the professor's authority because she felt he wasn't approachable. Without the professor intentionally cultivating a perception of approachability, students like Mercedes felt as though their concerns would not be heard. Finally, the physical layout of the classroom meant that only two students could be working with the material components of their robot at a time, while the other two used computers in the row ahead.

Lizzy's interview revealed challenges with the social component of the rhetorical infrastructure, in addition to issues with authority and operational infrastructures. Lizzy's team was composed of all women, but she described a perception shared by members of the team that "not all women" could succeed in the class and later in industry. This led to a contested sense of authority between two team members vying for the lead position. Operational challenges with the amount of time in class before their three-hour lab also had a significant impact on the team's attitudes.

Finally, Raina instead described her central challenge in the course as a function of the authority infrastructure. In particular, she explained how her instructor, Professor Smith, would consistently adopt a different tone and communication style with her team of all women than his tone when working with all-men or mixed-gender teams. Raina continued, "Because we're a group of all women, he expects us to not know how to do things, so when we don't know how to do things, it's like "of course you don't know."" While quick to say that she didn't think it was "malice" on the part of the instructor, rather implicit bias, Raina and her team's experience with her instructor's lowered expectations diminished their interest in participating in the class. Raina instead strategically relied on aspects of the social infrastructure to provide validation for her experiences, helping her feel less alone.

Two of the faculty participants are Professor Perbesi and Professor Brown, both of whom are involved in teaching the introductory engineering class. For Professor Perbesi, who identifies as an Asian woman, it was difficult to elicit the critical incident, even though the participant has taught the class for more than 5 years. When it was possible to pinpoint two incidents eventually, the incidents were both opposite to one another and counter-intuitive: (1) one about an assertive, outspoken woman student who had a "strong personality" leading her team; and (2) another "bubbly" woman student who was seen as not contributing to her team. Even though the student was active in social interactions, her team complained about her "contributions." Professor Perbesi brought forward the notion of "contribution," explaining her understanding of the relationship between personality, communication, and team contribution.

Professor Brown, who identifies as white and male, also started by talking about "contribution" as the major factor in teaming, regardless of identity. He also described his team assignment strategy as one with no attention to gender issues. Instead, he talked about identifying complementary skills within a team as something he would like to consider in the future in assigning teams. The interview with Professor Brown started with undermining identity issues; however, later in the interview, he started showing an appreciation for their importance of the issue. It was interesting how, toward the end of the interview when he described his teaching philosophy, he started linking his teaching approach to what he values outside teaching in his life. This was when his views of issues of equity started to surface.

Each participant's experiences contribute to a fuller sense of the challenges facing gendered and/or racially-minoritized students in introductory engineering programming courses. Interestingly, the authority and social infrastructures proved to be the most important for the three student participants, reflecting existing scholarship about the importance of community, mentorship, and student dispositions of confidence in programming education. The physical and operational infrastructures also discouraged active participation by all students, while challenges with the economic infrastructure didn't surface in these interviews.

7. Future work

Our ongoing research and the scholarly literature reveal the many ways women and gender-diverse students experience marginalization in the engineering classroom. However, engineering as a discipline is moving towards an increased appreciation for fostering diversity in engineering education. Diverse teams have a wider variety of perspectives and thought processes, leading to more favorable outcomes and products (Mallette, 2022). We believe that it is critical to pair this increased appreciation for the benefits of diverse teams with persistent commitment to creating more equitable educational experiences for marginalized and minoritized students. This project seeks to (1) illuminate women and gender-diverse students' experiences of marginalization during team communication in introductory engineering courses; (2) understand the complex rhetorical infrastructure surrounding these communicative exchanges; and finally (3) yield insight into specific interventions engineering educators can make to foster more inclusive communication in introductory classes. We are currently mapping the rhetorical infrastructure to find which elements are the most malleable and suited for our intervention. In the next phase of our study, we will implement targeted interventions to specific aspects of the introductory engineering classroom's rhetorical infrastructure and assess student communication outcomes following these interventions. We contend that there is a need for future research that provides specific and comprehensive strategies for fostering inclusive engineering education.

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