STUDIES IN ENGINEERING EDUCATION

Understanding Access to Learning Opportunities in Collaborative Projects: Gendered Social Hierarchies in Student Teams

EMPIRICAL RESEARCH

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ABSTRACT

Background: Prior research has demonstrated that participation in authentic learning experiences that resemble real-world engineering practice is key to unlocking the benefits of collaborative projects, such as design projects, for students in engineering. However, research has also documented that women are less likely to participate in key learning experiences in engineering design education, undermining the goals of project-based learning.

Purpose/Hypothesis: The purpose of this research study was to understand how social power dynamics shape the types of tasks allocated to students in teams and, by extension, students learning in collaborative engineering design projects. Drawing on the Model of Inequitable Task Allocation in Project-Based Learning, this work examines the role of prior experiences and skills, self-efficacy, and students' motivation in the process by which design tasks allocation is negotiated in student teams.

Design/Method: This ethnographic study entailed three data collection strategies: (a) ongoing observations of three focal design teams in a cornerstone design course, (b) one-on-one, semi-structured interviews with focal design team members, and (c) reflections from peer mentors who worked with focal and non-focal teams.

Results: Students reflected on their prior experiences and skills, and the confidence they gained or lacked as a result, when negotiating their roles in their teams. Importantly, students' valuation of their skills was gendered, where masculinized notions of engineering skills might lead women to underreport their skills during the role-negotiation process. Finally, while gendered patterns of marginalization and exclusion were apparent, I discuss the strategies women employed to exert influence over their team dynamics.

Conclusions: Ensuring equitable participation in collaborative projects is key to support learning for all students in collaborative projects. Understanding how students negotiate their roles and learning opportunities is an important step in supporting students' learning in collaborative projects.

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INTRODUCTION

In engineering education, collaborative, problem-based learning experiences, such as engineering design coursework, are proliferating across the curriculum. These experiences have been found to foster important academic, social, and affective outcomes key to preparing engineers for future academic success and professional practice (Kolmos & de Graaff, 2015; Mills & Treagust, 2003; Yadav et al., 2011). For example, existing research has found that participation in design coursework can foster teamwork and communication skills, motivation for pursuing engineering, engineering identity development, design thinking skills, and the integration of technical and non-technical knowledge (Dym et al., 2005; Norström, 2013; Wu et al., 2021). Perhaps most importantly, design coursework positions students to develop critical engineering skills, such as dealing with uncertainty, communicating various solution paths, evaluating ideas and knowledge claims, and engineering decision-making (Dym et al., 2005; Jonassen, 2015).

The degree to which students achieve these learning outcomes during team-based design experiences is informed by their opportunities to participate in authentic engineering-related tasks. For example, Dahlgren & Dahlgren (2002) note "learning in a context resembling that of professional work" (p. 112), as well as opportunities to "elaborate on and verbalize their knowledge" during social interactions with peers are key for fostering the retention and integration of knowledge in problem-based learning. In engineering design coursework, opportunities to communicate, clarify, and refine engineering ideas, as well as opportunities to raise questions in collaborative settings, are key to unlocking the benefits of collaborative projects (Li et al., 2019; Rohde et al., 2019). Moreover, opportunities to practice and refine technical skills (e.g., fabrication and computer-aided design skills) are important learning experiences for engineering students (Wu et al., 2021).

However, existing research suggests students' experiences in engineering design coursework is not equitable, leading to differential outcomes for minoritized students (e.g., students of color, women) in team-based, problem- and project-based learning settings (Keough et al., 2021; Wolfe & Powell, 2009). For example, research spanning the past several decades suggests students of color and women experience engineering education as hostile, unwelcoming, chilly and even violent along multiple dimensions (e.g., epistemic violence, emotional violence, physical violence) (McGee, 2016; Wolfe & Powell, 2009). Importantly, Nguyen and colleagues (2020) note that when students experience "social identity threat—a threat when people perceive that they may be devalued because of their social identities" (p. 387) – students feel a lessened sense of belonging, experience a lower desire to participate, and develop fewer skills. These studies suggest that social barriers to full participation undermine students' learning in team-based, problem-based learning settings.

Research in engineering education also indicates students from minoritized and marginalized backgrounds do not always have access to key learning opportunities, where disparities in task allocation result in differences in students' learning outcomes (Fowler & Su, 2018). For example, while Dahlgren & Dahlgren (2002) argued opportunities to elaborate on and verbalize knowledge is a key feature of problem-based learning, Hirshfield and Koretsky (2017) found gender differences in the content to students' speech in teams, where female students were more likely to discuss non-technical tasks and knowledge than their male counterparts. Similarly, existing research suggests women in engineering teams are more likely to be allocated non-technical tasks, such as notetaker or organizer, instead of the technical tasks that resemble authentic, professional engineering practice (Fowler & Su, 2018; Hirshfield & Koretsky, 2017).

Taken collectively, students' participation in key learning experiences in team-based, problem-based learning leads to a host of positive academic and social outcomes. However, in student teams, design decisions, including decisions about task allocation that lead to students' opportunities for learning, are often negotiated in a complex social process amongst students in and outside of the classroom (Campbell et al., 2019; Fowler & Su, 2018). The ways that power dynamics (e.g., racialized, gendered, and other social power dynamics) shape task allocation is key to understanding students' differential learning outcomes during collaborative engineering design projects (Fowler & Su, 2018). Thus, examining the teamwork dynamics by which students gain access to key learning opportunities in their teams is a key area for engineering education research. This research was guided by the following question:

1. What are the characteristics of the process by which student teams negotiate task allocation in collaborative design projects?
2. How do gendered performance expectations and social power dynamics shape task allocation in collaborative projects in engineering?

CONCEPTUAL FRAMEWORK

Fowler and Su's (2018) Model of Inequitable Task Allocation in Project-Based Learning (MITA) provided the conceptual framework for this study. In the model, Fowler and Su describe student-level factors, as well as team-based processes that inform both initial and longitudinal task allocation in collaborative projects, which influences students' learning. Importantly, I utilized the MITA model because it draws attention to the role of gender in individual- and team-level processes that shape task allocation and, as a result, students' learning, in teamwork pedagogies. The MITA model is depicted in Figure 1.

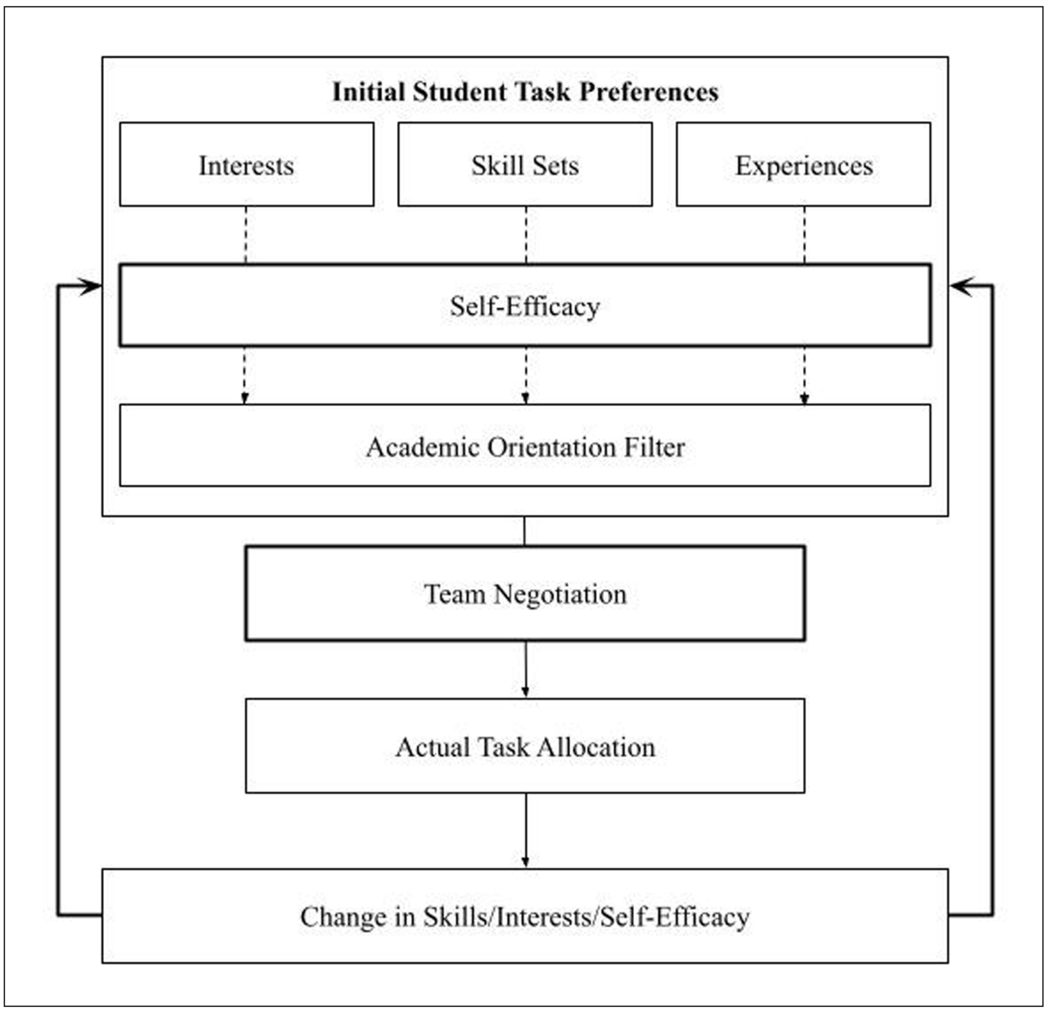

Figure 1 Model of Inequitable Task Allocation in Project-Based Learning.

STUDENT-LEVEL FACTORS

Fowler and Su (2018) begin by acknowledging that the differences students bring to collaborative project teams, including differences in initial interests, skills, prior experiences, and self-efficacy, inform their individual and team behaviors. Whereas some instructors might begin by assuming

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students are blank slates to be inscribed by learning experiences over the course of the collaborative project, Fowler and Su posit that initial interests, skills, and experiences inform team negotiations about task delegation and ultimately the tasks (i.e., learning experiences) students afford to one another in their respective teams.

Fowler and Su (2018) also argue that the ways initial interests, skills, and prior experiences inform task allocation is a function of students' self-efficacy beliefs. Bandura (1986) defined self-efficacy as one's beliefs about their ability to carry out a plan of action to achieve a desired goal. Consistent with the MITA model guiding this work, Sheu and colleagues (2018) note that self-efficacy beliefs are informed by four sources – mastery experiences, vicarious learning, verbal persuasion, and affective elements. For example, prior mastery experiences – success and failures at particular tasks or courses of action (Sheu et al., 2018) – inform one's self-efficacy, where positive mastery experiences (e.g., performing well on an exam, successfully completing a design task) are positively associated with self-efficacy, and negative experiences (e.g., performing poorly on an exam, unsuccessful design ventures) are negatively related to one's self-efficacy beliefs. The MITA model captures this dynamic by suggesting prior experiences and related self-efficacy beliefs inform students' valuations of their skills (i.e., what I think I am good at) and in turn their academic motivations for learning (i.e., continue to do what I am good at or enhance skills I think I am bad at).

Understanding students' prior experiences and skills as a function of their self-efficacy is important when examining task allocation in student teams for three reasons. First, according to Bandura (1986) and Sheu and colleagues (2018), mastery experiences, which are represented by prior experiences in the MITA model, are directly related to one's self-efficacy and have the strongest relationship with one's self-efficacy when compared to indirect sources such as vicarious experiences and verbal persuasion. Second, students' self-efficacy beliefs, which are informed by their prior experiences and their valuations of their skills, are related to the types of tasks students pursue, where students who have more confidence that they can complete a particular task are more likely to pursue a task and more likely to be undeterred by negative experiences (Bandura, 1986). Finally, students with prior positive mastery experiences and related self-efficacy beliefs, in negotiation with teammates, might be more likely to engage in tasks for which they have stronger self-efficacy beliefs than their teammates. Conversely, students with negative prior experiences and negative self-efficacy beliefs might be more likely to avoid related tasks in team-based projects (Bandura, 1986).

ACADEMIC ORIENTATION FILTER

Fowler and Su (2018) then argue that students interpret individual-level factors (i.e., their interests, skills, and prior experiences) through an academic orientation filter, which entails their motivations for learning. For example, students who might wish to take on a particular learning opportunity but are motivated by performance-avoidance due to a fear of being perceived to be incompetent by their peers, might be less likely to take on the very tasks they wished to pursue. Another example entails students who lack prior skills and experiences but are mastery oriented (i.e., motivated to master new skills or knowledge), which might thus make them more likely to pursue related tasks.

Fowler and Su (2018) note that the academic orientation filter is not socially neutral. Rather, societal norms, such as racialized and gendered performance expectations, inform students' academic orientations, applying different social pressures on students to behave and perform, particularly in teamwork settings. For example, the authors describe the "performance-avoidance" orientation, wherein students are motivated to avoid appearing incompetent or less intelligent than their peers. McGee and Martin (2011) noted that these pressures to "always be on point" are an undue "burden" that some students, particularly those from minoritized backgrounds, used "to rescue themselves from being judged as less worthy or less capable of academic excellence" (p. 1367). Thus, the social pressures students experience, which are informed by racialized and gendered societal norms, might inform students' academic orientations and behaviors in teamwork settings.

The academic orientation filter is important as an analytical lens for examining the role of equity issues in student teams. Simply measuring or examining students' academic motivations alone might miss the ways racialized and gendered performance expectations shape students' individual and collective behaviors in teams. For example, numerous scholars have charted racial/ethnic and gender differences in students' engineering self-efficacy beliefs (e.g., Concannon & Barrow, 2009; Henderson et al., 2022) and motivational influences (e.g., Kolmos et al., 2013). However, simply noting the differences does little to explain how and why race/ethnicity and gender shape interactions, decision-making, task allocation, and ultimately students' learning in collaborative projects.

In engineering project teams, individual characteristics like race/ethnicity and gender often translate into performance expectations, where White and male status carry with them societal assumptions about competence and intelligence, particularly when compared to students from minoritized racial/ethnic and gender backgrounds (Joshi, 2014; Keough et al., 2021; Nguyen et al., 2020). These performance expectations entail social consequences. For example, the consequences of "being wrong" or appearing ill-prepared might be harsher for minoritized students than their White male counterparts, leading some minoritized students to prioritize performance-avoidance or the obsessive need to "always be on point" as described by McGee and Martin (2011). Thus, understanding how these pressures appear in collaborative project teams, as well as the strategies students might employ to navigate them, is an important area for educational research.

TEAM-LEVEL FACTORS

TEAM NEGOTIATION AND TASK ALLOCATION

Finally, the patterns of tasks allocated to students in collaborative projects is interpreted as an ongoing negotiation among team members. Literature on teamwork in collaborative projects outlines several teamwork processes that shape team negotiation and decision-making. For example, Casakin & Badke-Schaub (2015) point to shared mental models (i.e., task models, process models, team models) that inform individual and collective approaches to design processes, where individual and collective understandings about design tasks, appropriate methods and practices for solving specific tasks, and knowledge about other team members' roles and abilities, inform team behaviors. Others have examined communication patterns, team climate, psychological safety, team conflict, and team self-regulation (e.g., den Otter Emmitt, 2007; Stempfle & Badke-Schaub, 2002). All these lines of literature point to the idea that individual behaviors are best understood in the social and cultural context of the team.

Still, this study was concerned with the ways that social power dynamics and inequities might inform how students, both at the individual and team level, think about and determine task allocation. For example, existing research documents the ways that characteristics like racial/ethnic or gender identity carry with them societal performance expectations related to racialized and gendered assumptions about competence, intelligence, prior experience, and general ability (Paik & van Swol, 2021; Simpson et al., 2012). In engineering contexts, these assumptions often point to implicit beliefs that Whites and males are expected to be more competent in engineering tasks (e.g., design tasks, building tasks) than their counterparts from minoritized racial/ethnic and gender backgrounds (Keough et al., 2021). These assumptions are often manifested in task allocation, performance outputs, and patterns of influence in teams (Engle et al., 2014; Keough et al., 2021).

In this research, I conceptualized tasks to be both opportunities to participate in the collaborative design process (e.g., opportunities to contribute ideas during team meetings), as well as the opportunities taken by individuals or a subset of the team to complete portions of the team project separately from the team (e.g., the person assigned to review presentation slides). Moreover, the tasks allocated to students were documented across three broad categories – design, building, and documentation tasks. For example, design tasks included opportunities to communicate, clarify, and refine design ideas during the ideation process, as well as the technical tasks related to the design process such as developing the team's computer-aided design (CAD) model. Building tasks included opportunities construct various elements of the team's design (e.g., laboratory work). Finally, documentation tasks included tasks such as developing reports and presentations for class assignments, as well as notetaker roles during team discussions and testing. Importantly, the MITA model suggests an iterative process of understanding team-level task negotiation in which the types of learning experiences afforded to students (i.e., the tasks allocated to them), shape their resulting skills, interests, and self-efficacy beliefs, which in turn informs their later academic orientations, later team negotiation, and later task allocation. Thus, students allocated CAD modeling tasks are more likely to develop skills, interests, and confidence related to CAD modeling, which inform later academic orientations and resulting task allocation.

This research focused on these broad categories of tasks due to their importance as learning opportunities in design teaching and learning (Dym et al., 2005), as well as existing research suggesting that characteristics such as race/ethnicity and gender can shape the degree to which students gain access to these opportunities. For example, Engle and colleagues (2014) argued that negotiation in student-led discussions consists of four components: (a) the negotiated merit of each student's contributions, (b) each students' intellectual authority, (c) the degree to which students have access to the conversational floor, and (d) students' spatial privilege. However, existing research suggests that even when students have relatively equal access to the conversational floor, the types of communication tasks they take on differ along gendered lines (Hirshfield & Koretsky, 2017). This underscores the need to focus not just on the degree to which people have the floor, but the actual tasks they are completing when they have the floor, a central goal of the MITA framework. Guided by the MITA framework, the goal of this study was to examine how students allocate tasks on teams, as well as to examine how power dynamics shape the relationship between students' initial predispositions, academic orientation, team negotiation processes, and ongoing task allocation.

POSITIONALITY

My interest in this research stems from my experiences in undergraduate engineering education. As a Black male engineering student, I was keenly aware of the ways my Blackness shaped the ways I "showed up" in my engineering teams, including my awareness of structural diversity in the discipline, the ways I communicated my ideas with teammates, the anxiety I felt around appearing angry or aggressive during team debates, and other factors shaping my experiences in teams. As I began to understand that race shaped how I engaged in teamwork in ways largely invisible to my teammates, I also began to examine ways that gender, masculinity, and broader disciplinary cultures shaped how my teammates and I interacted and communicated. As a result, analyzing power – racial power, gendered power, and power at the intersection of race and gender – became a centerpiece of my work as an engineering education researcher.

My emerging understanding of racialized and gendered power led me to a set of methodological decisions herein. For example, I chose a critical ethnographic approach to this project. Madison (2012) notes that critical ethnography "begins with the ethical responsibility to address processes of unfairness and injustice" (p. 5). However, I was aware that my lens as a Black male might cause me to see race where my White colleagues did not, or to miss sexism where my non-male colleagues thought it apparent. Moreover, I understood that my Blackness might lead others – participants, evaluators, advisors – to assume an interest in subverting what Keough and colleagues (2021) call White male dominance in engineering, leading some students to "perform equity" in my presence as a researcher. As such, to honor my goal of examining and addressing processes of unfairness and injustice, I employed strategies – reflexive practices, rapport building, member checking – both to ensure quality, but also to remain steadfast in my goal of describing how the culture of engineering education reinforces racialized and gendered social power.

This document, which focuses heavily on the role of sex/gender and sexism in teamwork, reflects feedback provided by two White women colleagues with whom I have written and published in the past. These colleagues, who have experiences teaching in engineering and conducting engineering education research, engaged in reflective conversations throughout the data collection, analysis, and reporting processes, as well as read drafts of this manuscript. In their feedback on initial drafts of this work, one colleague noted a persistent bias in my writing – in my describing patterns of sexist behaviors, I routinely failed to name the male students enacting the sexist pattern. Grammatically, what appeared to be recurring passive voice was, upon reflexive engagement and introspection, gendered bias on my own part. I recognized that this persistent pattern in my writing reflected at least four implicit biases and errors in my perspective as a man engaged in ethnographic research. First, and most obviously, was my grammatical error of using passive voice. Second, was my unwillingness to name or label students whom I had grown to care for over the course of the project as "sexist" or "racist," even passively. Third was a concern about reviewer defensiveness – I recognized that reviewers might object to labeling any behavior sexist without the most overt evidence. Finally, I recognized my own defensiveness – just as critical race scholars note a tendency to reason away racism by ascribing race-less explanations to race-based incidents (Bonilla-Silva, 2015), I reflected on my tendency to reason away sexism by leaving space for gender-less explanations to gender-based patterns of exclusion and marginalization (i.e., sexism). In response to these critiques and feedback, I revised this document to directly name the patterns and actors I documented, and that students described, in the findings discussed in later sections.

METHODS

RESEARCH CONTEXT

This research was part of a larger, mixed-methods study examining teamwork processes in engineering design project teams. While the focus of this article is task allocation in student design teams, the goal of the broader study was to understand how power dynamics in teams shaped teamwork processes (e.g., communication, idea uptake, idea enactment, design decision-making). The context for this study was a first-year engineering design cornerstone course, ENG1, at a large, Midwestern, public university. ENG1 is described as a team-based design-build-test-communicate course. ENG1 was delivered around an underwater vehicle design project, wherein 12 design teams consisting of four or five students all attempted to address a design challenged centered on remotely operated vehicles (ROVs). Each team in the course was assigned a peer mentor – a student who had taken ENG1 in a prior semester – who could offer feedback and guidance on the team's design process.

Teams were formed by the instructional team based on several pedagogical goals, such as a desire to avoid isolating women with all-male teammates, team diversity, living arrangements, and safety concerns. I selected three teams—one per section of the course—based on invitations (i.e., only teams that expressly invited me to observe were considered for the study), and diversity along several dimensions (e.g., racial/ethnic, gender, epistemic diversity). The three focal teams were also representative of the course. For example, five of the 12 teams were all-male (e.g., The Yachtsmen), and the other seven teams consisted of at least 2 female students (e.g., Team Mobula and Team Surge).

The course was designed around a set of deliverables organized to facilitate individual and team-level design processes. For example, at the beginning of the project, and prior to students meeting their project teams, students were asked to submit an Individual Design Proposal (IDP) of their initial ROV design ideas. Following the submission of their IDPs, students were assigned final project teams where they began by completing an initial "Meet the Team" assignment during which instructors asked students to discuss their prior experiences, the skills they brought to their team, the skills they hoped to refine or gain, and any passions they brought to the project. Next, drawing on their IDPs, each team was to develop a Preliminary Design Review (PDR) presentation by narrowing their individual ideas into a collection of 2–3 preliminary ideas. Finally, student teams were to produce a Detailed Design Review (DDR) and Critical Design Review (CDR), which entailed narrowing their ideas to a single concept.

As the project progressed, students began to delegate tasks (e.g., design, building, and communication tasks) in their teams. The tasks were generally delegated to address important deliverables (e.g., building assignments, the Design Reviews described above, the course-ending

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competition). The goal of this research was to document the process by which students negotiated and ultimately delegated tasks in their teams.

DATA COLLECTION

This work draws on ethnographic data, where I used three strategies for data collection: (a) ongoing observations of three focal engineering design teams, (b) one-on-one post-experience interviews with members of the focal design teams, and (c) reflections from the course's peer mentors. The full corpus of data included observations of 45 team meetings lasting anywhere from one to five hours. I also conducted interviews with all 15 members of the focal teams. Finally, nine of the 12 peer mentors submitted electronic journals, although two of the three peer mentors who did not submit journals were peer mentors to focal teams.

Team Observations

First, I engaged in ongoing observations of three focal teams – Team Mobula, Team Surge, and The Yachtsmen (pseudonyms) – over the course of the project. For each focal team, I observed meetings during lecture, technical communications, and laboratory sessions (i.e., all formal class time), as well as informal meetings organized by students outside the formal class time. Demographic information about the three focal teams can be found in Table 1 below.

Table 1 Demographic Characteristics of Focal Teams.

Note: All names, including team names, are pseudonyms adopted after data collection.

	RACE/ETHNICITY	SEX
Team Mobula		
Matt	White	Male
Chelsea	White	Female
Max	Asian	Male
Addy	Black	Female
Kevin	Asian	Male
Team Surge		
Danish	Asian	Male
Lauren	White	Female
Stephanie	White	Female
Ryan	White	Male
Rehman	Asian	Male
The Yachtsmen		
Kyle	White	Male
Paul	White	Male
John	White	Male
Seth	White	Male
Cam	White	Male

I was able to observe all but one focal team meeting due to a scheduling conflict between Team Surge and The Yachtsmen. During team meetings, my role was largely that of an observer, and I made efforts not to disrupt the flow of conversation, interactions, decision-making, and other aspects of the design process. However, I did intervene in moments (e.g., in the laboratory) during which I believed students' safety was at risk. Moreover, there were moments during which my presence clearly shaped team dynamics. For example, during one particularly contentious Team Surge meeting as students began to argue somewhat vociferously, one team member, Ryan, gestured in my direction and reminded the team, "Guys. I don't think we should fight over this," implying he wanted to avoid explosive "fights" in my presence.

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I documented my observations in an open-ended observation protocol that focused my attention on various aspects of the design process. Germane to this research, I documented mechanisms (e.g., conversations, interactions, behaviors, patterns of inclusion or exclusion) by which students allocated tasks over the course of the project.

Interviews

At the end of the term, I conducted semi-structured interviews with each of the 15 students in the three focal teams to understand students' reflections on the design process, team interactions, and their learning. During interviews, which lasted between approximately 40 and 75 minutes, I asked students to reflect on the types of tasks they contributed to most and least during their project experiences, how tasks were delegated, whether there were tasks they had hoped to participate in but did not, and whether there were tasks they hoped to avoid but still took on. As one of the goals was to understand the role of race/ethnicity and sex/gender in the design process, I asked each student to discuss the role they believed race/ethnicity and sex/gender played in their experiences. Finally, I also asked students to discuss what they believed they had learned about engineering, engineering communication, and design over the course of the project.

During interviews, I also engaged in a member checking process as an early trustworthiness technique. I drafted brief individual and team profiles offering broad, preliminary overviews of my perceptions of each student and their respective teams. I offered each student the opportunity to read both their own profile, as well as their team's profile, offering feedback on my preliminary interpretations and findings.

Peer Mentor Journals

Each team in the course was assigned a peer mentor who met with their assigned team approximately one to two times per week during laboratory sections and team meetings. Since I was unable to conduct observations on all 12 teams in ENG1, I asked peer mentors to reflect on their experiences interacting with teams to assess whether patterns I saw in the focal teams were consistent across the non-focal teams. To do so, I met with three peer mentors during the prior semester to pilot the journal prompts, ensuring that prompts were clear and not confusing. Journal prompts asked peer mentors to describe their experiences with their teams, including any patterns of interactions, communication, leadership, and task delegation they observed. I also asked explicit questions about the role of race and gender in teams, asking peer mentors to reflect on the role students of color and women played in their respective teams. Peer mentors submitted journals once at the end of the term.

DATA ANALYSIS

Qualitative data analysis proceeded in three stages. I began by transcribing handwritten fieldnotes. After transcribing fieldnotes, I followed the systematic process outlined by Emerson and colleagues (1995) for facilitating the data analysis in ethnographic studies. First, I read and re-read fieldnotes and reflective journals to elaborate and refine initial jottings given further observations over the course of the term. Moreover, I documented my reflections in analytical memos, returning to my memos over time to elaborate on ideas, or put ideas in richer context given other analytic memos or analyses, as I analyzed further data.

Second, I engaged in an iterative process of coding the fieldnotes, interviews, and peer mentor journals. Since this research was part of a larger study that included an examination of the types of tasks students took on in collaborative project teams, I began by using a set of *a priori* codes that reflected how tasks were delegated in each team, patterns of communication and decision-making, and epistemic cognition at both the individual and team levels. For example, code examples capturing the tasks students were delegated included the task types (e.g., design-related tasks, building tasks, technical communication tasks), and how tasks were delegated (e.g., granted, taken, avoided, denied). I documented the reading and coding processes, and ideas, themes, and descriptions I developed during the coding and analysis process in reflective memos. Example codes are listed in Table 2 below.

PARENT CODE	CHILD CODE	DEFINITION	EXAMPLE
Action Opportunity	Action Opportunity for Design	A student takes or is granted an opportunity to contribute to design tasks (e.g., presenting ideas, developing CAD model)	[Student Interview]: I just started to do more. I felt like I was actually contributing, especially once I got started on the CAD model…
	Action Opportunity for Building	A student is takes or is granted the opportunity to contribute to building tasks for the team.	[Peer Mentor Journal]: [Student A] is a bit quieter, so I didn't see her contributing idea-wise as much during build sessions, but [Student B] definitely took a bit more of a leading role in actually physically building the ROV.
	Action Opportunity for Technical Communication	Student takes or is granted an opportunity to contribute to technical communications tasks (e.g., report writing, developing presentations).	[Peer Mentor Journal]: [Student] really stepped up in making sure that the reports were done on time and getting people to plan when they were going to meet and who was working on what.
Background Characteristics	Salience of Gender	Student discusses the salience of gender in engineering or engineering design.	[Peer Mentor Journal]: The girls in the group had a lot of great ideas however at times I had to encourage them to keep expressing them especially after rather tense moments when ideas where discarded.
	Engineering Background	Student discusses engineering-related background experiences.	[Student Interview]: I took two years of CS in high school. I feel no confidence in my CS skills.
	Lack of Skills/ Experience	A student discusses the role inexperience played in their individual or team design process.	[Student Interview]: Well, I guess I feel like for a student that doesn't have a ton of experience, it's all just stuff that you might just see in passing.
Affective Elements	Confidence	A student discusses the degree to which they are confident taking on design, build, or communicate tasks.	[Student Interview]: Definitely grown in those areas, but definitely not confident enough to do a lot of it by myself.
Task Delegation	Task Delegation	A student discusses the ways in which tasks were delegated on their team.	[Student Interview]: The roles kind of came naturally, I guess, when delegating.
	Task Delegation Equity	A student discusses their perceptions about whether task delegation was equitable in their team.	[Fieldnotes]: As they start to build the vessel, the team seems intent on ensuring that every gets equal opportunities to work on the building. They worked out the total number of cuts necessary to build the concept vessel and divide the total equally amongst them.

Table 2 Example Codes and Definitions.

Note: The task delegation and action opportunities codes captured different elements of the design process. Specifics about task delegation (i.e., person X did A and B tasks) were coded as "Action Opportunities". The task delegation code captured students' broader discussions about the team's approach to delegation. Sometimes these two things were discussed at once.

Finally, I synthesized findings across data sources. For example, I compared students' reflections about task delegation in the focal team interviews to patterns of task delegation documented in my fieldnotes, noting similarities and differences in students' reflections from my own commentary. I also compared peer mentor observations to my own observations to ascertain if patterns I documented in my fieldnotes were also observed in the non-focal teams. An example of the synthesis process is presented in Table 3 below.

As I developed themes surrounding the role of prior experiences, skills, self-efficacy, academic orientation, and demographic characteristics (e.g., race/ethnicity, gender) in collaborative projects in engineering, I returned to all qualitative data sources to separate discrepant evidence, noting places where my expectations about the role of these factors appeared to undermine the theoretical framework and existing literature (i.e., subjectivist and intertextual reflexivity) (Alexander, 2003; Denzin, 1997). Finally, while the coding and analysis process was undertaken alone, I engaged in reflexive practice by discussing the analysis process and emergent findings with research collaborators and advisors.

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EXCERPT FROM FIELDNOTES	RELATED INTERVIEW QUOTES
Kyle began the (Re)Introduction exercise, offering that, as a result of his experiences growing up and working with his father, he is "good at putting stuff together." Kyle said he would like to expand his CAD skills during the project. John followed Kyle by offering that he brings mathematics and programming skills to the project. Like Kyle, John said he would like to expand his CAD knowledge over the course of the project. Paul followed John and discussed his experiences growing up a farm and how they had prepared him for work on the team. "I grew up on a farm, so I'm good at building stuff." Seth followed by offering that he brought computer science/coding skills to the team. Seth added that he wished to expand his building skills—"my skills in the lab and putting things together." Cam chimed in that he brought CAD skills to the project, adding that he wished to expand his coding and building knowledge.	**Kyle:** Because I definitely did want to work on the CAD a little bit more and develop my skills in CAD, because I took CAD in high school like sophomore year, but I haven't really done much with it since then.
	John: Whereas I know Seth and Paul, they got almost no experience in that CAD process. My thoughts were not like I want to keep this all for myself.
	Seth: I did CAD for those first two labs, and I was not very excited about it. I did not like it very much. It was definitely very frustrating for me all the parts together and I can't imagine how much of it Cam had to go through doing that, but just the fact that he'd done that before and he seemed like he wanted to do that for the team definitely helped us out a lot.

Table 3 Example Synthesis of Fieldnotes, Interview Quotes, and Peer Mentor Journals about the role Prior Experiences and Academic Orientations in Task Delegation.

FINDINGS

CHARACTERISTICS OF THE TASK ALLOCATION PROCESS: THE ROLE OF PRIOR EXPERIENCES AND THE ACADEMIC ORIENTATION FILTER

Unsurprisingly, students' prior experiences played a key role in their design thinking and working relationships, including the ideas they pursued at the individual and team levels, as well as the process of negotiating task allocation. Some examples mirrored a straightforward interpretation of the role of prior experiences in students' academic orientation and task allocation, where students with prior mastery experiences in a task (e.g., coding), were more likely to take on related design tasks (e.g., coding tasks), due to their familiarity and confidence with those tasks. For example, Cam's teammates quickly identified him as an expert in SolidWorks®, and as a result, the team asked Cam to take on CAD modeling tasks that required SolidWorks® skills. Cam, who shared that he had "a fair bit of CAD experience," reflected on the role his prior skills played in his working relationships:

> …I figure once we got to more technical aspect of it [i.e., the design process] that once I was able to contribute to something I feel like I started to feel more valued because I was really the only one who knew how to CAD or how to do something in CAD. Once I'd finished the design and about, I think it was a few days after they said, "Oh we need to do this in CAD," and they just said, "Oh it looks great. Good job." I just felt like okay I contributed something so…

That Cam was delegated the CAD modeling tasks due, in part, to his prior skills and self-efficacy is unsurprising. However, Cam's prior experiences be understood in the context of his team, as well as the skills, self-efficacy, and academic orientations of his teammates. For example, Seth expressed that he had struggled with early CAD modeling assignments, and had hoped to avoid the CAD modeling tasks during the project:

> I did CAD for those first two labs, and I was not very excited about it. I did not like it very much. It was definitely very frustrating putting all the parts together and I can't imagine how much of it Cam had to go through doing that, but just the fact that he'd done that before and he seemed like he wanted to do that for the team definitely helped us out a lot.

The MITA model posits that students' individual prior experiences and related self-efficacy beliefs inform their academic orientation, as well as team negotiation of task allocation. This finding supports the MITA model's presupposition. Seth's prior experiences and related lack of confidence, as well as his perceptions regarding Cam's prior experiences, informed his academic orientation (i.e., performance-avoidance), making it more likely that Cam, the student with more prior experiences and confidence, would take on the CAD modeling tasks.

Still, other examples suggest the relationship between prior experiences, academic orientations, and task allocation are not always straightforward, underscoring the importance of the team negotiation process. Kyle, who had discussed a desire to gain CAD modeling skills during the early "Meet the Team" exercise, and reiterated that desire during his one-on-one interview, lamented the fact that he had done less of the CAD modeling that he had hoped:

> I honestly did really want to work on the CAD a little bit more...But yeah, once I saw that he [i.e., Cam] was able to sit down and work on that and that kind of helped him move forward I was like, "Okay. We'll just kind of let him do that and I'll check in on him and we'll talk to him about it but just kind of let him do his thing as far as that goes." Because I definitely did want to work on the CAD a little bit more and develop my skills in CAD, because I took CAD in high school like sophomore year, but I haven't really done much with it since then.

Kyle's prior experiences informed his mastery orientation—his desire to master prior CAD modeling skills. However, the team's perceptions of Cam's skillsets, coupled with a desire to get Cam more involved in the design process, led The Yachtsmen to delegate the CAD modeling tasks to Cam. A similar dynamic played out with regards to coding tasks. Seth, who acknowledged that he would not be the strongest coder on the team given Paul's and John's prior experiences, similarly lamented missed coding opportunities due to both the COVID-19 pandemic and the fact that Paul and John were more likely to contribute to the coding tasks:

> The only thing is I feel like I knew going into the project that my coding skills weren't going to be a big part of this project because most of it wasn't coding...Even with the coding, I knew I wasn't going to be the most experienced coder on the team either, because Paul and John had both taken the programming class ahead of me last semester, so I knew they were also very solid programmers and they would have helped contribute to that too. So it wasn't like the programing skills were what were going to set me apart in the team.

Seth similarly articulated a concern that his teammates brought more experiences with laboratory machinery, which might inform the types of tasks he was allocated:

> ...I remember the first time we had lab it was a little striking for me, because I quickly realized that it seemed like everybody had experience with the lab equipment before and everybody sort of knew what they were doing with at least some of the lab things just from design teams or prior experiences. Like Paul said during that lab, like he grew up on a farm and I was very much new to all of that, so it was a little worrying for me to come into that clearly being the least experienced in the lab parts of it and I wanted to grow in my lab experience at building and putting that together was exciting for me.

As a result of his perceptions of his teammates' prior experiences and skills, Seth deferred the coding and building tasks to those teammates, choosing instead to take on tasks related to the teams' calculations, for which he believed his brought prior skills and experiences were sufficient. Moreover, Seth acknowledged that while he had wanted to grow in his laboratory skills, he and his teammates took on "part of the project that they were comfortable with," leading to his role as the person in charge of calculations:

> I knew I had strengths in more like calculation type stuff, so I was fine doing the nitty gritty Google sheets for coming up with center [of gravity, of buoyancy] calculations and cost calculations. So, I think everybody sort of just had a good sense of what role they wanted to take from the beginning and then it was pretty easy to split up from that.

Importantly, Seth connected this decision to his learning in the course, suggesting that while he had gained some skills in the coding and building tasks he had deferred to other teammates, he still had not grown comfortable enough to complete the tasks himself:

> Definitely grown in those areas [i.e., building tasks], but definitely not confident enough to do a lot of it by myself. Having the experience from my team members definitely helped me in the project and helped the team get everything together so quick. If everybody on the team had my level of experience in using tools and putting everything together in the lab I'm sure we would not have been the first team to assemble the ROV.

Other examples similarly displayed how the assumption that prior experiences and related confidence might lead to allocation of related tasks may not be straightforward. For example, Rehman (Team Surge) shared that he drew on his prior experiences designing ROVs, and that those prior experiences gave him confidence (i.e., self-efficacy in the MITA model) that his ideas were sound:

> I actually found that [i.e., prior experiences building ROVs] was really helpful because especially when we get to the individual design part, most of my stuff I had already tested out and knew it was going to work because I had already built this.

Rehman, who acknowledged "taking a backseat" in the task allocation process, described how his prior experiences in project teams led him to a performance-avoidance orientation, not due to a lack of confidence, but due to his reflections on his prior experiences:

> From a group in high school to a group in college, especially in [University] where everyone's very smart, it was definitely much better. It was really good, I found. Usually in high school, I'd be doing everything and this time I was definitely a role player in that group. I think I played a role pretty well. I definitely wasn't the number one...

Other students similarly shared how prior experiences shaped their motivations for particular tasks. Kevin (Team Mobula) shared:

> I have experience in high school on a robotics team, so I was looking at the timeline and I realized that there wasn't going to be enough time to do anything fancy, so for the individual design proposal I just went for a very simplistic design that had degrees of freedom that we needed, and I was going to focus mostly on the driving aspect...

Kevin described organizing his work both to gain opportunities to practice driving the team's ROV, a task he had not been able to complete thoroughly during his prior experiences, as well as to avoid onerous re-design tasks that had plagued his prior design experiences. As a result, Kevin was unwilling to pursue complex ideas, and deferred some design thinking and idea selection to his teammates with these goals in mind:

> One of us had to give eventually and I didn't want to... As long as I got to build and drive it around a little bit, even if it wasn't at the competition, I didn't really mind giving up my idea to build someone else's because I know that when you suggest an idea and can invest time in it, it really hurts to just be outvoted and for the team just to go a different direction when you've already invested in one idea. In my competition days I would take our robot, scrap it and rebuild it all in a single week so I don't get too emotionally invested in designs.

Both examples demonstrate the role prior experiences play in shaping students' design self- and team-efficacy, as well as their individual academic orientations in collaborative projects. According to the MITA model, students' prior experiences inform their motivations for learning (i.e., their academic orientation). For Rehman and Kevin, their prior experiences and resulting confidence led them to performance-avoidance orientations for particular tasks. Rehman's prior experiences building ROVs led him to be unmotivated to pursue design tasks for which he had been previously heavily involved (i.e., in high school). Rehman's academic orientation (i.e., his comfort

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and willingness to avoid tasks) was informed by his prior experiences in design teams. Similarly, Kevin's prior experiences designing robots and his resulting lack of confidence that the team could complete a complex design during the term informed his avoidance orientation. Kevin's academic orientation (i.e., avoiding more complex designs, deferring ideation tasks to teammates, organizing for testing tasks) was informed by his prior challenges in design teams in high school. Both students' experiences appeared to shape their approach to the team negotiation process, as Rehman sought a "back seat" to his team's task delegation process, and Kevin deferred ideation discussions to his teammates.

These findings underscore the important role of the academic orientation filter in the MITA model, as well as the complexity of the relationship between prior experiences, academic orientation, and task allocation in teams. The assumed relationship between prior experiences, skills, self-efficacy, and task allocation, where positive prior experiences and strong confidence translate into related task allocation, did not always hold in the focal teams. While some students (e.g., Cam and CAD modeling, Seth and calculations) were allocated tasks by their teammates due to their prior experiences, and some students (e.g., Seth and CAD modeling, Kevin and complex design ideas) avoided tasks due to negative prior experiences, the opposite relationship was also true. Some students (e.g., Rehman taking a "back seat") avoided tasks precisely because they brought prior mastery experiences and therefore did not feel a strong motivation to participate in those tasks. Their academic orientations – their motivations for learning – appeared to shape their individual and collective approaches to negotiating task allocation, which this study views as important learning experiences.

THE ROLE OF GENDER IN THE MITA MODEL

The core purpose of the MITA framework is to examine inequities in the ways that tasks are allocated in teams. Fowler (2020) notes that the ways inequities appear in teams may be visible (e.g., biased language such as racial slurs, intimidation, physical violence), or invisible to instructors (e.g., psychological safety, beliefs about performance expectations). Findings in this research pointed to the ways that gender influenced the factors described in the MITA model (e.g., self-efficacy, academic orientation, team negotiation). For example, the ways students described their interests, skillsets, and prior experiences was also informed by gendered performance expectations, where the assumed relationships between prior skillsets and experiences and eventual task allocation during the collaborative project (i.e., that a person with prior skills in CAD modeling might be more likely to take on the CAD modeling tasks during the project) did not hold for all students.

For example, during the early "Meet the Team" exercise, two women on Team Surge told their teams that they held no engineering skills, which I documented in my fieldnotes:

> Stephanie began the discussion by joking that she "brings no engineering skills, but lots of enthusiasm to the team." She added that she would like to expand her knowledge in building... Lauren followed by saying that, like Stephanie, she does not bring engineering skills, but is good at organizational tasks, like "spreadsheet stuff." She added that she wants to expand her skills at building.

However, upon reflection during post-experience interviews, Stephanie indicated that she had undersold her skills due to her low self-efficacy:

> Something that I've been thinking about...The idea that when I think I don't have engineering skills, I think that I might have the same amount of engineering skills as a lot of the other people on our team. Yeah. In retrospect. I took two years of CS [i.e., computer science] in high school. I feel no confidence in my CS skills. I took as much CS as probably anybody else on our team...I think that I am much more likely to evaluate my engineering technical skills as lower than other people with the same technical skills.

When describing her lack of confidence, Stephanie centered the role that internalized gender performance expectations played in shaping her evaluations of her prior experiences and skills. Stephanie shared:

> I think it might be gender-based. I'm the only person from my high school who's going to a STEM school. I'm the only one of any of my friends from high school, mostly girls. I don't know how to verbalize it. I think that I downplay that because I have a lot less confidence in those skills. I think that I would have been able to do anything that anyone else did. I don't know. I think I'm prone to that.

As the MITA framework suggests, examining Stephanie's prior experiences alone does not entirely address the ways those skills and experiences shaped her individual and collective approach to the design process. Instead, the role of Stephanie's prior experiences and skills is best understood as a function of her self-efficacy beliefs, which were informed by gendered performance expectations and contributed to her academic orientation (i.e., her preferences for gaining skills in building and later avoidance of CAD modeling tasks). Initially, Stephanie's self-efficacy beliefs, which she believed were informed by gendered performance expectations, led her to devalue her prior experiences, which in turn informed how she represented her skills during the team negotiation process. While this supports the Fowler and Su's (2018) claim in the MITA model that self-efficacy shapes the team negotiation process in ways that might be invisible to observers and team members, it challenges previously understood relationships between prior mastery experiences and self-efficacy.

Moreover, Fowler and Su (2018) argue that the MITA model is iterative, with prior experiences and skills informing initial self-efficacy, academic orientation, and team negotiation, and task delegation, as well as later self-efficacy, academic orientation, team negotiation, and task delegation. Stephanie's experience in the context of Team Surge's task negotiation underscores the iterative nature of the MITA model. Stephanie's representation of her skills resulted in her being delegated almost sole responsibility of the team's CAD modeling tasks. However, as the team struggled to develop their CAD model in time for an important presentation, Stephanie's self-efficacy for CAD modeling faltered, and the task was ultimately reassigned to Ryan, which I documented in my fieldnotes:

> Following their meeting on Sunday, the team went their separate ways to work on individual tasks. [Note: I was very surprised that the team left one person – Stephanie – to the CAD model given that they all expressed a lack of confidence.] Stephanie reported to the team (via GroupMe) that she was struggling with the CAD model. Ryan and Lauren participated in this discussion, and Lauren offered to step in to offer support. Ryan specifically referenced a problem with the joints the team will need for the trapezoid frame – "They're impossible to make in CAD lol." After Stephanie reiterated the CAD struggles, Ryan, Stephanie, and Lauren began to offer of solutions. The conversation suggests Ryan and Stephanie do not want to abandon the plan they made during the meeting, but the CAD struggles appear to be taken seriously, and they begin to discuss suitable alternatives for the upcoming Detailed Design Review presentation.

This series of events underscores the iterative nature of the MITA model. Stephanie's initial devaluation of her coding skills during early team discussions led her to take on tasks for which she was also not confident, resulting in negative experiences in CAD modeling, which itself resulted in a second reshuffling of task allocation in Team Surge. Over the course of the project, Stephanie's struggles with CAD modeling negatively impacted her self-efficacy, which informed her academic orientation, leading her to avoid further CAD modeling task. Eventually, the CAD modelling task was turned over to Ryan for completion.

Gender also appeared to shape team discussions and negotiation processes that resulted in patterns of exclusion from some tasks. One such pattern occurred in moments during which the work and contributions of women were more heavily scrutinized or were changed by men without a woman's knowledge. For example, during my observations of one Team Mobula meeting, I documented an exchange in which both Addy and Chelsea noticed that their male teammates had revised their contributions to the team's presentations without their knowledge. Moreover, Chelsea described how she interpreted Matt's behavior in the context of her prior engineering experiences, as well as the historical context of women's experiences in engineering more broadly:

> Matt would go over my work every time. I don't think I've written one section that he hasn't redone completely. Or with the control box that I designed; he just redid the whole thing. I was really frustrated with that... I feel that's really condescending to be like, to not think that I can handle the work myself. It's one thing if I had a wrong number, yeah, please fix that. And I appreciate that. But when it's little stuff and he's reading my whole section, it's just the work that I did was a waste of time, and it wasn't good enough. That was really frustrating throughout the whole project. And especially being a girl in engineering, it's really irritating when men just do my work for me. I did not like that.

These incidents were part of a larger pattern in Team Mobula in which women appeared to be excluded from decisions and speaks to the ways that gendered power dynamics might shape students' learning in invisible ways. Patterns of exclusion were, at times, physical (i.e., men making design decisions in women's absence). For example, during one Team Mobula meeting, I documented an exchange between Matt and Chelsea, in which Matt informed the team that he had made changes to their design ahead of their presentation:

> Matt asked to start the meeting by reviewing the slides, but Chelsea asked to wait for Max and Addy, who had not yet arrived in the room. Matt agreed to this but began to review the slides anyway. Matt noted that "we made changes to the design last night" to Chelsea, and Kevin adding "and we will probably change the custom part design." Matt reassured Chelsea quickly, "but not now, though!" These design changes happened seemingly without input from the rest of the team.

These incidents speak to the ways that patterns of marginalization can be both visible and invisible in student teams. Publicly, and visibly, it appeared Chelsea was engaged in particular tasks, contributing equally to her team's project. Privately, however, her male teammates revised Chelsea's and Addy's work without her knowledge and contributions should be seen as a moment in which both women missed out on an important learning opportunity, which Chelsea appeared to interpret as a judgement of her adequacy as an engineer. Moreover, the process of learning to communicate, negotiate, clarify, and refine ideas is critical to students' learning, particularly in engineering design (Dym et al., 2005). That some of these opportunities appeared to occur in Chelsea's and Addy's absence means, implicitly, that they missed out on some of the experiences critical to achieving the learning goals of collaborative projects (Li et al., 2019).

During my observations, I documented times in which I perceived Addy was being excluded, either implicitly or explicitly, from the team's work. For example, during one team meeting, during which Team Mobula made important design decisions in Addy's absence, I wrote:

> At the start of the meeting, after a short discussion, Chelsea and Matt (announced by Matt) decided the team must decide on a design during the meeting. Max immediately expressed concern about this since Addy is not present. Max asked the team to find a way to include Addy, perhaps by having her call in. Matt says he assumes she cannot call in since she never offered, and that it would be too much a hassle. Addy, then, will play no role in the team's biggest decisions.

In Addy's absence, the team also began to assign tasks in the project, with Matt assigning himself the critical CAD modeling task and assigning Addy tasks that he noted were "the easiest way to do something if you were not here."

Addy's exclusion from the meeting was part of a pattern that some of her teammates acknowledged. While Addy was clear that she did not feel like her teammates had treated her differently on racialized or gendered grounds, her teammates acknowledged both distrust of her work and a collective failure to fully include her in team discussions. For example, Max, reflecting on this and other incidents that occurred during the project, acknowledged they "didn't do a good job of bringing her into discussions" and recognized that some experiences may have left her "feeling like she didn't really belong." These findings suggest the team negotiation process is another place in the MITA model in which gender might shape teams' task allocation decisions.

GENDERED POWER DYNAMICS AND TASK ALLOCATION IN TEAMS

Other patterns of marginalization and exclusion included patterns of interruption well-documented in literature on women's experiences in male-dominated spaces like engineering. During my observations, I began to document what I called a "culture of interruption," which entailed moments during which opportunities to contribute ideas to team discussions were cut short by interruptions. For example, during one laboratory session, I wrote:

> Stephanie began explaining her design decision about the placement of the joints. As Stephanie was speaking, Ryan again interrupted to describe his and Rehman's argument. Stephanie became exceptionally frustrated by the interruption, and I heard her sarcastically say, "I guess I won't get to finish a sentence."

Interpreting Matt's and Ryan's behaviors was a methodological challenge. First, I understood that Matt and Ryan were unlikely to report that their behaviors (e.g., interruptions, changing working) occurred *because* Chelsea and Stephanie were women. Still, both Chelsea and Stephanie interpreted the incidents in the broader context of women's' experiences in engineering. Here, I engaged in reflexive practice – intertextual reflexivity, in which I situate my interpretations in broader literature, and subjectivist reflexivity, in which I engaged in self-critique (Alexander, 2003; Denzin, 1997). While I acknowledged that it might not have been Matt and Ryan's intentions to enact normative sexist behaviors against the women in their teams, the women in their teams clearly interpreted these experiences within a broader context. Just as Chelsea pointed to the role of gender in the meaning she made of Matt's repeated revisions to her work without her knowledge, Lauren and Stephanie also pointed to the role of gender in their interactions with their teammates. In their interviews, both men and women pointed to patterns of interruption during team negotiation, discussing how such patterns informed their team working dynamics. Lauren (Team Surge) shared:

> I did feel like I wasn't really being heard with some of the design report decisions. It felt like I was giving out a lot of ideas. Ryan would be the one to say, "I don't think we should do that." Actually, we talked about it. I messaged him. I'm like, "I'm getting frustrated. I feel like my ideas aren't being heard, and it's kind of unfair."

On reflecting on these incidents, Ryan acknowledged patterns of interruption, and pointed to lessons from instructors about the experiences of women in engineering:

> I think Stephanie might have saw it as me trying to talk over her because she is a woman in engineering, and historically they might not be treated in the same regard. I think she was very aware of that, whereas I wasn't aware. It wasn't something I was trying to do. There were a couple of times when [the men] were talking, and she would say, "Don't talk over me." ... It's something they're [i.e., women] conscious of, and therefore you want to be conscious of it.

This research presumes opportunities to communicate, clarify, and refine ideas in collaborative project teams, particularly with those who are different, as important learning experiences (Kuh, 2008). Taken collectively, patterns by which women were excluded from decision-making, and the thinking and discussions decision-making entails, and patterns of interruption undermine women's opportunities to participate in those important learning experiences equitably. These findings suggest the relationship between self-efficacy, academic orientation, team negotiation, and task allocation is muddied by the role of gender and gendered power dynamics in teams.

GENDERED STRATEGIES FOR EXERTING INFLUENCE OVER TASK ALLOCATION

I also documented strategies that women employed to exert influence over task allocation and team decisions. One such example, which I documented during my observations of the three focal teams, entailed moments in which women, who were strategically placed on teams with at least one other woman, "cleared the floor" for other women by subverting attempts to undermine or interrupt their women counterparts' ideas. For example, during one team meeting, while Lauren (Team Surge) began advocating for an idea, Ryan, her male counterpart, attempted to interrupt Lauren's justification. In that moment, Stephanie, a female student on Team Surge, stepped in to support Lauren – "Wait! Lauren wasn't done." – thereby clearing the floor for Lauren's ideas to be heard.

The pattern by which women appeared to work together to take on particular learning opportunities was one of several seemingly strategic approaches I documented in my fieldnotes. For example, during one team meeting, when Team Surge was clarifying their ROV frame concept, two male students, Rehman and Danish, contributed similar ideas for a modification to the frame. I documented the exchange in my fieldnotes:

> As the team stared at their near-completed frame, Danish broke in – "Oh I have an idea!" He suggested they consider adding bars to the top of the frame for adjustable heave thrusters. Lauren, with aid from Stephanie (who quieted the table for Lauren to speak), said the idea would not work because there was not enough space. Stephanie agreed. It appeared Stephanie and Lauren had spent some time together after Rehman had pitched a similar idea to formulate a clear, coherent, practiced objection. Hence, Stephanie was so confident that Lauren would articulate a concise, agreed upon objection that she actually cleared the floor for Lauren to speak.

I returned to these moments during interviews following the conclusion of the project, and members of Team Surge reflected on the role of gender in their team working dynamics. Stephanie shared:

> Lauren and I often, she would say something and I would agree and then it would take a lot more convincing with these other people…Maybe with the frame when I was so against the octagon [sic], because it was such a pain in the ass. People weren't like, "We have to do this." Lauren came up with that new design and I was super onboard because it was so much less work. It wound up working out.

While reflecting on Team Surge's discussion about their frame design, Lauren shared how she had discussed her ideas with Stephanie first to clarify her ideas, making it more likely that she would be heard on her team:

> I also mentioned to Stephanie I had an idea that might make it easier. She had said she can't take on any more, so I decided to just draw it up, and wait until I could see people in person, because I figured trying to have that kind of discussion over chat would not go over well, and people, I think, just the difficulty of trying to convey your ideas and get people on board, it's just so much harder over text. I really wanted people to hear me out, because I thought it was a really good idea, and it would solve all our problems.

These moments were also documented in other teams in both my observations and peer mentor reflections on non-focal teams. For example, one peer mentor described a clear pattern of divides on their assigned team:

> Right away it was obvious that [Woman A] was the team leader. Everyone looked to her for validation and advice. She would delegate out tasks, but she always gave herself the hardest task. The group kind of split into 3 groups. [Woman A] and [Woman B] would work on one project. [Man A] and [Man B] were another group. [Woman C] seemed to be the odd one out…

These gendered divides in task allocation had at least two effects on team working processes that I documented in my fieldnotes. First, such divides ensured that some aspect of the project uniquely belonged to the women on the team. Second, these gender divides also ensured patterns of interruptions, argumentation, and marginalization by men ceased. Collectively, these strategies underscore the importance of considering gender in the MITA model, where task allocation is informed, in part, by both gendered patterns of exclusion and marginalization, as well as women's

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strategies for resisting those patterns of exclusion and marginalization during the team negotiation process.

Still, while women appeared to exert influence strategically by clearing the floor or pairing for design tasks, the patterns by which men exerted influence over task allocation also called attention to the mediating role of gender in task allocation and learning opportunities in engineering teams. For example, Matt, a White male member of Team Mobula, was described by team members as a "*de facto* team leader." When I asked members of Team Mobula how this came to pass, one member offered that it was due to "subtle factors", such as his friendliness and the fact that he "seemed like he knew what he was doing." This description of male teammates occurred twice during the Design Experience Interviews with members of Team Mobula. Kevin, an Asian male member of Team Mobula, was given almost sole responsibility for a major portion of the project. Max offered that the team trusted Kevin, that the trust was "implicit," because "we just kind of knew that he knew what he was doing." Importantly, this "implicit trust," which Max referred to as "a psychological question," resulted in Kevin taking on tasks for which other students felt they lacked prior experience or confidence. Max shared:

> And so to be honest, Kevin kind of just took control of the whole 3D printed part thing, where it looked like the thruster guards and all that, because honestly, none of us really had experience with 3D printing. And so Kevin kind of took charge on that part...Oh, yeah. I definitely trusted him, just because he ... It's hard to explain what it's like. You can tell that he knows what he's doing, I guess. And it's something he really likes doing too.

That Matt and Kevin assumed leadership roles and tasks on their teams due, in part, to implicit assignments of competence from their teammates points to the ways gendered performance expectations shape task allocation in student teams. In engineering, where White, Asian, and male are associated with competence (McGee et al., 2022), this research suggests that these characteristics might also have translated into the task delegation to students in their respective teams.

Conversely, the patterns I described by which women exerted influence over their teams appeared to come with social consequences. For example, one peer mentor described how one woman on his team "seemed to be most confident in what was going on," but later described the same woman as "talking down to most of her teammates" and "dominating design discussions in general," a familiar description of women who assume leadership roles and exhibit non-stereotypical traits (e.g., assertiveness, decisiveness, confidence) (Layne, 2010).

The social consequences of gendered patterns of influence were apparent throughout my observations and students' reflections. For example, Addy, who had not been present when tasks were delegated, came to believe that workloads had been relatively equal and expressed few concerns about the team's working process. However, when reflecting on the team's task delegation strategy, Matt acknowledged that Addy would "get the work that no one wants to do," which he believed Addy was happy to do. Still, this task delegation process later resulted in concerns about workload equity, a concern Addy later expressed in her interview:

> Well, I feel like sometimes people didn't say what needs to be said because I know lots of times, I didn't get to [the team assessment tool] to do my team check and then see the equal workload, like bar going down. I mean that's not something anyone ever complained about on the group chats or in person. I was just wondering why someone or people would feel like there's a problem in the group and not say anything about it.

Perhaps the most jarring example of the social consequences of women's strategies for exerting influence over teams occurred during one Team Surge meeting, which Rehman referred to as the team's "worst day." The team had been engaged in a contentious discussion about the dimensions of their ROV frame to finalize their CAD model and begin building tasks. As the argument became more intense, Stephanie's insistence on completing the task, which had been delegated to her,

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resulted in one student, Rehman, leaving the room in frustration. Rehman reflected on the incident during his interview:

> I think our biggest argument was definitely that day in the lab when Stephanie was freaking out about dimensions…We were all trying to work together on the dimensions. Stephanie was really insistent that only her do the dimensions because she thought that everyone else would do them, that it would get messed up, which she might have a point but either way… I remember just feeling like, I need to go the bathroom, Stephanie's pissing me off right now. But she really wanted one person to do the dimensions and then everyone else just don't worry about it…

Rehman, who referred to Stephanie as "stubborn" and "freaking out," even as he acknowledged support for her perspective, reflected normative responses to women exerting influence that might negatively affect women's willingness to participate in engineering teams. Taken collectively, these findings suggest women's strategies for exerting influence over task delegation and, by extension, gaining access to learning opportunities in team-based design settings, might come with particularly deleterious social consequences that shape team communication, interactions, and working processes.

DISCUSSION AND IMPLICATIONS

The MITA model posits task allocation in student design teams as a function of students' prior experiences and skills, which informs their self-efficacy beliefs and their resulting motivations for learning. This research offers support for the MITA framework, suggesting that students do indeed reflect on their prior experiences and related skills and confidence when framing their motivations and negotiating task allocation in engineering teams. However, this research extends the framework by suggesting that students understand their skills and experiences in comparison to their teammates, shaping the negotiation process that results in various patterns of task allocation.

Research on students' self-efficacy consistently points to the idea that students who have strong, positive self-efficacy beliefs, which is directly related to prior mastery experiences (Sheu et al., 2018), are more likely to engage in related tasks and are more likely to persist through challenges (Bandura, 1986). This research problematizes that presupposition in at least two ways. First, students' self-efficacy beliefs must be understood in the context of their teams, where their perceptions of their teammates' experiences and skills shapes how they view their own skills. For example, when students believed their teammates brought stronger skills and experiences to their teams, they often deferred related tasks to others. This could be seen when the Yachtsmen delegated CAD modeling tasks to Cam due to his demonstrated skills, as well as when Seth avoided the same tasks due to his negative mastery experiences and perceptions of his teammates' skills during course assignments.

Second, while it is unsurprising that students were more likely to take on tasks for which they had prior experiences and confidence or avoid tasks for which they lacked prior experiences and confidence, their individual academic orientation still played a role in the task negotiation process. While some students' lack of prior experiences and skills, and low confidence, led them to a performance-avoidance orientation (e.g., Seth avoiding CAD modeling), other students (e.g., Kyle) articulated that their lack of mastery experiences led them to a performance-mastery orientation. If it is the case that instructors wish to foster learning environments wherein students develop engineering-related skills holistically, instructors should tend to the ways academic orientations shape how students participate in their teams by encouraging students to reflect on their prior engineering skills, identify gaps in their knowledge and skills that they hope to address, and decrease performance pressures that negatively impact participation and contributions from minoritized students disproportionately.

Still, students' academic orientations did not always translate into task allocation in teams due, in part, to other team dynamics, including processes of exclusion, patterns of interruption, and gendered valuations of prior skills and experiences, playing out in their respective teams. These findings underscore the need for future research to further examine and document team working relationships and interpersonal dynamics in students' access to important learning opportunities. To date, research on conflict, shared mental models, and communication have all been examined as important factors in teamwork in engineering (Casakin & Badke-Schaub, 2017; den Otter Emmitt, 2007; Stempfle & Badke-Schaub, 2002). However, the ways that these processes are shaped by internal and structural power dynamics is underexplored in engineering design education research.

GENDERING THE MITA MODEL

Existing research indicates that women are more likely to take on less technical tasks, as well as less favorable tasks, in student design teams in engineering (Fowler & Su, 2018; Hirshfield & Koretsky, 2017). This research extends those findings by examining the negotiation process to understand how individual and team-level factors shape the task negotiation and allocation process. Like their male counterparts, women pointed to their prior experiences, skills, and self-efficacy when describing their motivations for learning and eventual task allocation. However, the ways that these factors shaped the negotiation process were at times troubled by gendered performance expectations, patterns of exclusion, and a culture of interruption.

For example, this research conceived of opportunities to contribute to design tasks, such as communicating, clarifying, refining, and implementing design ideas, as central tasks, and thus important learning opportunities, in engineering design education. Dym and colleagues (2005) described design thinking as an iterative process of divergent-convergent thinking, where divergent thinking "takes place in the concept domain" where "the questioner attempts to diverge from facts to the possibilities that can be created from them," and convergent thinking entails attempts to "converge on and reveal 'facts'" (p. 105). However, in design teams, where problems are ill-structured and entail multiple solutions paths, concepts and answers do not have one verifiable, true answer (Dym et al., 2005; Jonassen, 2000, 2015). Thus, opportunities for the entire team to communicate, clarify, refine, and implement ideas (i.e., divergent thinking) hold critical importance for team design decision-making (i.e., convergent thinking) and, by extension, students' learning in team settings.

The utility of the MITA model in this research is that the model offers factors – gender, self-efficacy, team negotiation, and academic orientation – that muddy the widely held view of design thinking as an iterative process of convergent-divergent thinking in that the nature of divergent-convergent thinking in teams is negotiated and entails gendered power dynamics that shape whose thinking is even present, as well as whose thinking is elevated or marginalized during the negotiation process. If, as Stephanie suggested, some students "can't finish a sentence," or are excluded entirely from design discussions on gendered grounds, the iterative process of divergent-convergent thinking is disrupted, and students' learning is undermined. In this study, that this appeared to happen to women more often indicates that gender is an important factor disrupting the iterative process of divergent-convergent thinking.

However, this research also suggested pedagogical approaches for mitigating the role gender might play in disrupting design thinking in students' teams. One common pedagogical strategy for addressing patterns of marginalization for women in collaborative project teams is for instructors to assign women to teams that avoid "stranding" them alone with all male teammates (Keough et al., 2021). This research offers promising support for such pedagogical practices. In this work, women appeared to work together to exert influence over task delegation negotiations, thereby leveraging each other to gain access to learning opportunities.

Karpowitz and Mendelberg (2014) noted that "authority is the expectation of *influence*" and that "men and women tend to enter the room with different levels of authority." However, Karpowitz and Mendelberg also noted one can act in a way that enhances one's own authority and that "others can act in ways that enhance or detract from another's authority" (p. 18). Unsurprisingly, known behaviors that contribute to the marginalization of the work and contributions of women in engineering, such as patterns of interruption and exclusion from decision-making, were exhibited in the collaborative project teams examined in this study. These behaviors threatened to undermine women's access to important learning opportunities. However, the patterns by which women worked together, often with the effect of gaining more full participation in their design teams was one way that women enhanced each other's authority and had clear implications for task allocation and, by extension, their learning. Still, instructors should be attuned to the potentially negative social consequences associated with the behaviors women employed to gain access to design tasks, as well as patterns of implicit bias that elevated men to positions of leadership in design teams.

Moreover, gender influenced the factors described in the MITA model in ways outside of interpersonal interactions, ways that were internal to the students in the project teams. Quantitative research is inconsistent regarding gender differences in students' engineering self-efficacy (e.g., Concannon & Barrow, 2009; Henderson et al., 2022; Marra et al., 2009; Schar et al., 2017). However, this research indicates students' self-efficacy beliefs stemming from their prior experiences or inexperience might be understood through a gendered lens, where societal performance expectations might lead women to underrate their skills and experiences in the social context of engineering teams. Stephanie, for example, clearly related her lack of confidence to her status as a woman in engineering and the marginalizing experiences that status has entailed. Similarly, Chelsea clearly understood processes of exclusion (e.g., changing her work without her knowledge) as typical of broader patterns of gendered marginalization in engineering.

In a study examining the racialized experiences of Black doctoral students in STEM disciplines, McGee and colleagues (2022) argued that structural racism is a source of impostorism, "described as an individual's intellectual self-doubt and fear of failure, which is characterized by concern that others have overestimated their talents or abilities and therefore feel defrauded" (p. 488). In this view, structural issues, such as the lack of Black students and faculty in STEM, stereotyping, attrition amongst Black students and faculty, and other issues lead to anxiety about one's belonging in the discipline. Findings in this study suggest that a similar dynamic for women in engineering might play out in collaborative projects, and perhaps engineering more broadly, where anxiety about one's prior skills and belonging might lead women to underestimate or underreport their skills. For example, Marra and colleagues (2009) noted that "women who leave engineering consistently express less confidence in their abilities than the men and women who stay, regardless of the fact that their academic performance is the same or better" (p. 29). This research extends those findings by illustrating how such dynamics appear in interpersonal interactions, particularly in collaborative design projects, with consequences for students' learning.

Herein lies the importance of the academic orientation filter for examining how students' self-efficacy contributes to task allocation and student learning. If it is true that women are more likely to underrate their prior skills, the consequences for teamwork pedagogies abound. Students in this study who lacked confidence to pursue particular tasks appeared to be more likely to bring a performance-avoidance orientation to those tasks, deferring the tasks to students they believed were more competent or confident. From a pedagogical perspective, this is worrying given that some students, particularly men, were perceived to be more competent for "implicit" or "psychological" reasons – not reasons supported by evidence of their competence. Thus, important learning experiences were afforded to students based on perceptions, not necessarily evidence, of their competence, meaning some students did not fully participate, or were altogether absent, from those experiences.

FUTURE DIRECTIONS

Students' participation in tasks in collaborative projects is a key part of their learning. These tasks include opportunities to communicate, elaborate, and clarify ideas, as well as physical tasks such a building and tinkering in laboratories. However, inequitable task allocation, particularly for minoritized students (e.g., students of color, women), threatens to undermine students' learning in teamwork pedagogies. This research joins a long history of literature examining the ways gendered power dynamics and sexist behaviors in engineering undermine the work and contributions of women in the discipline. Future research might examine interventions for preempting and addressing the ways characteristics such as gender, race, disability, and other characteristics contribute to inequities in task allocation.

Educators might also consider ways to help students frame their prior experiences, skills, and learning goals at both the individual and team levels. Simply asking students to reflect on their prior experiences and skills might exacerbate inequities in task allocation since this leaves students alone in making sense of their prior experiences in the context of their teams. This is particularly important given the finding that some students, particularly minoritized students, might underrate their skills, leaving them to delegate meaning learning experiences to others in their teams. Ultimately, this work suggests engineering design educators, as well as educators in other disciplines drawing on teamwork pedagogies, should understand individual characteristics and experiences, as well as how students make meaning of their personal characteristics and experiences in specific team contexts.

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COMPETING INTERESTS

The author has no competing interests to declare.

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REFERENCES

Alexander, B. K. (2003). (Re)Visioning the ethnographic site: Interpretive ethnography as a method of pedagogical reflexivity and scholarly production. *Qualitative Inquiry, 9*(3), 416–441. DOI: https://doi.org/10.1177/1077800403009003006

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall. DOI: https://doi.org/10.5465/amr.1987.4306538

Bonilla-Silva, E. (2015). The structure of racism in color-blind, "post-racial" America. *American Behavioral Scientist, 59*(11), 1358–1376. DOI: https://doi.org/10.1177/0002764215586826

Campbell, C., Roth, W., & **Jornet, A.** (2019). Collaborative design decision-making as social process. *European Journal of Engineering Education, 44*(3), 294–311. DOI: https://doi.org/10.1080/03043797.2018.1465028

Casakin, H., & Badke-Schaub, P. G. (2015). Team mental models in design problem solving: An interdisciplinary perspective. In A. M. Columbus (Ed.) *Advances in psychology research* (pp. 169–182). Hauppauge, New York: Nova Science Publishers. https://novapublishers.com/shop/advances-in-psychology-research-volume-106/

Casakin, H., & **Badke-Schaub, P.** (2017). Sharedness of team mental models in the course of design-related interaction between architects and clients. *Design Science, 3*(14), 1–21. DOI: https://doi.org/10.1017/dsj.2017.15

Concannon, J. P., & **Barrow, L. H.** (2009). A cross-sectional study of engineering students' self-efficacy by gender, ethnicity, year, and transfer status. *Journal of Science Education and Technology, 18*(2), 163–172. DOI: https://doi.org/10.1007/s10956-008-9141-3

Dahlgren, M. A., & **Dahlgren, L. O.** (2002). Portraits of PBL: students' experiences of the characteristics of problem-based learning in physiotherapy, computer engineering and psychology. *Instructional Science, 30*(2), 111–127. DOI: https://doi.org/10.1023/A:1014819418051

den Otter, A., & **Emmitt, S.** (2007). Exploring the effectiveness of team communication: Balancing synchronous and asynchronous communication in design teams. *Engineering Construction and Architectural Management, 14*(5), 408–419. DOI: https://doi.org/10.1108/09699980710780728

Denzin, N. K. (1997). Chapter 7: Ethnographic poetics and narrative of the self. In N. K. Denzin (Ed.), *Interpretive ethnography: Ethnographic practices in the 21st century* (pp. 199–228). Thousand Oaks, CA: Sage. https://sk.sagepub.com/books/interpretive-ethnography. DOI: https://doi.org/10.4135/9781452243672.n7

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & **Leifer, L. J.** (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education, 94*(1), 103–120. DOI: https://doi.org/10.1002/j.2168-9830.2005.tb00832.x

Emerson, R. M., Fretz, R. I., & **Shaw, L. L.** (1995). *Writing ethnographic fieldnotes* (2nd edition). University of Chicago Press. https://press.uchicago.edu/ucp/books/book/chicago/W/bo12182616.html. DOI: https://doi.org/10.7208/chicago/9780226206851.001.0001

Engle, R. A., Langer-Osuna, J. M., & **McKinney de Royston, M.** (2014). Toward a model of influence in persuasive discussions: Negotiating quality, authority, privilege, and access within a student-led argument. *Journal of the Learning Sciences, 23*(2), 245–268. DOI: https://doi.org/10.1080/10508406.2014.883979

Fowler, R. R. (2020). There are many "I's" in team: Considering individual experiences in team-based pedagogy. [Seminar presentation]. University of Michigan Engineering Education Research Seminar Series, Ann Arbor, MI, United States. Available at: https://www.youtube.com/watch?v=a9S41aQ43nQ. Accessed on 15 June 2022.

Fowler, R. R., & **Su, M. P.** (2018). Gendered risks of team-based learning: A model of inequitable task allocation in project-based learning. *IEEE Transactions on Education, 61*(4), 312–318. DOI: https://doi.org/10.1109/TE.2018.2816010

Henderson, T. S., Shoemaker, K. A., & **Lattuca, L. R.** (2022). Career calculus: Assessing the psychological cost of pursuing an engineering career. *Journal of Engineering Education, 111*(4), 770–791. DOI: https://doi.org/10.1002/jee.20474

Hirshfield, L., & **Koretsky, M. D.** (2017). Gender and participation in an engineering problem-based learning environment. *Interdisciplinary Journal of Problem-Based Learning, 12*(1). DOI: https://doi.org/10.7771/1541-5015.1651

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational Techonology Research and Development*, *48*(4), 63–85. DOI: https://doi.org/10.1007/BF02300500

Jonassen, D. H. (2015). Chapter 6 – Engineers as problem solvers. In A. Johri & B. M. Olds (Eds.), *Cambridge Handbook of Engineering Education Research* (pp. 103–118). Cambridge University Press. DOI: https://doi.org/10.1017/CBO9781139013451.009

Joshi, A. (2014). By whom and when is women's expertise recognized? The interactive effects of gender and education in science and engineering teams. *Administrative Science Quarterly*, *59*(2), 202–239. DOI: https://doi.org/10.1177/0001839214528331

Karpowitz, C. F., & **Mendelberg, T.** (2014). Introduction. In C. F. Karpowitz & Mendelgberg (Eds.), *The silent sex: Gender, deliberation, and institutions,* (pp. 1–7). Princeton University Press. https://www.jstor.org/stable/j.ctt7zvffd. DOI: https://doi.org/10.1515/9781400852697

Keough, M., Hirshfield, L., & **Fowler, R.** (2021). How male students talk about the female student experience on teams. *Paper presented at 2021 ASEE Virtual Annual Conference Content Access, Virtual Conference*. https://peer.asee.org/37256

Kolmos, A. & **de Graaff, E.** (2015). Chapter 8 – Problem-based and project-based learning in engineering education. In A. Johri & B. M. Olds (Eds.), *Cambridge Handbook of Engineering Education Research* (pp. 141–160). Cambridge University Press. DOI: https://doi.org/10.1017/CBO9781139013451.012

Kolmos, A., Mejilgaard, N., Hasse, S., & **Holgaard, J. E.** (2013). Motivational factors, gender, and engineering education. *European Journal of Engineering Education, 38*(3), 340–358. DOI: https://doi.org/10.1080/03043797.2013.794198

Kuh, G. D. (2008). High impact educational practices: What they are, who has access to them, and why they matter. *Association of American Colleges and Universities.* Retrieved from: http://provost.tufts.edu/celt/files/High-Impact-Ed-Practices1.pdf

Layne, P. (2010). Perspectives on leadership from female engineering deans. *Leadership and Management in Engineering, 10*(4), 185–190. DOI: https://doi.org/10.1061/(ASCE)LM.1943-5630.0000083

Li, H., Öchsner, A., & **Hall, W.** (2019). Application of experiential learning to improve student engagement and experience in a mechanical engineering course. *European Journal of Engineering Education,* 44(3), 283–293. DOI: https://doi.org/10.1080/03043797.2017.1402864

Madison, D. S. (2012). Chapter 1: Introduction to critical ethnography: Theory and Method. In D. S. Madison (Ed.), *Critical ethnography: Method, ethics, and performance* (pp. 1–16). Sage Publications. DOI: https://doi.org/10.4135/9781452233826.n1

Marra, R. M., Rodgers, K. A., Shen, D., & **Bogue, B.** (2009). Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy. *Journal of Engineering Education, 98*(1), 27–38. DOI: https://doi.org/10.1002/j.2168-9830.2009.tb01003.x

McGee, E. O. (2016). Devalued Black and Latino racial identities: A by-product of STEM college culture. *American Educational Research Journal, 53*(6), 1626–1662. DOI: https://doi.org/10.3102/0002831216676572

McGee, E. O., Botchway, P. K., Naphan-Kingery, D. E., Broackman, A. J., Houston, S., II & **White, D. T.** (2022). Racism camouflaged as impostorism and the impact on Black STEM doctoral students. *Race Ethnicity and Education, 24*(4), 487–507. DOI: https://doi.org/10.1080/13613324.2021.1924137

McGee, E. O., & **Martin, D. B.** (2011). "You would not believe what I have to go through to prove my intellectual value!" Stereotype management among academically successful Black mathematics and engineering students. *American Educational Research Journal, 48*(6), 1347–1389. DOI: https://doi.org/10.3102/0002831211423972

Mills, J. E., & **Treagust, D. F.** (2003). Engineering education – is problem-based or project-based learning the answer? *Australasian Journal of Engineering Education, 3*(2), 2–16.

Norström, P. (2013). Engineers' non-scientific models in technology education. *International Journal of Technology and Design Education*, *23*(2), 377–390. DOI: https://doi.org/10.1007/s10798-011-9184-2

Nguyen, H., Wu, L., Fischer, C., Washington, G., & **Warschauer, M.** (2020). Increasing success in college: Examining the impact of a project-based introductory engineering course. *Journal of Engineering Education, 109*(3), 384–401. DOI: https://doi.org/10.1002/jee.20319

Paik, J. E., & **van Swol, L. M.** (2021). The effects of expertise, status power, and language use on perception of task partner. *Journal of Language and Social Psychology*, *41*(4). DOI: https://doi.org/10.1177/0261927X211067249

Rohde, J., Musselman, L., Benedict, B., Verdín, D., Godwin, A., Kirn, A., Benson, L., & **Potvin, G.** (2019). Design experiences, engineering identity, and belongingness in early career electrical and computer engineering students. *IEEE Transactions on Education, 62*(3), 165–172. DOI: https://doi.org/10.1109/TE.2019.2913356

Schar, M., Gilmartin, S. K., Rieken, B., Brunhaver, S. R., Chen, H. L., & **Sheppard, S.** (2017). The making of an innovative engineer: Academic and life experiences that shape engineering task and innovation self-efficacy. *Paper presented at the 2017 ASEE Annual Conference & Exposition*. Columbus, OH. DOI: https://doi.org/10.18260/1-2--28986

Sheu, H., Lent, R. W., Miller, M. J., Penn, L. T., Cusick, M. E., & **Truong, N. N.** (2018). Sources of self-efficacy and outcome expectations in science, technology, engineering, and mathematics domains: A meta-analysis. *Journal of Vocational Behavior, 109*, 118–136. DOI: https://doi.org/10.1016/j.jvb.2018.10.003

Simpson, B., Willer, R., & **Ridgeway, C. L.** (2012). Status hierarchies and the organization of collective action. *Sociological Theory, 30*(3), 149–166. DOI: https://doi.org/10.1177/0735275112457912

Stempfle, J., & **Badke-Schaub, P.** (2002). Thinking in design teams – an analysis of communication. *Design Studies, 23*(5), 473–496. DOI: https://doi.org/10.1016/S0142-694X(02)00004-2

Wolfe, J., & **Powell, E.** (2009). Biases in interpersonal communication: How engineering students perceive gender typical speech acts in teamwork. *Journal of Engineering Education, 98*(1), 5–16. DOI: https://doi.org/10.1002/j.2168-9830.2009.tb01001.x

Wu, L. L., Fischer, C., Rodriguez, F., Washington, G. N., & **Warschauer, M.** (2021). Project-based engineering learning in college: Associations with self-efficacy, effort regulation, interest, skills, and performance. *SN Social Sciences, 1*(12), 1–20. DOI: https://doi.org/10.1007/s43545-021-00286-4

Yadav, A., Subedi, D., Lundeberg, M. A., & **Bunting, C. F.** (2011). Problem-based learning: Influence on students' learning in an electrical engineering course. *Journal of Engineering Education, 100*(2), 253–280. DOI: https://doi.org/10.1002/j.2168-9830.2011.tb00013.x

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