



Building Inclusion in Engineering Teaming Practices

EMPIRICAL RESEARCH

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ABSTRACT

Background: Teamwork is a commonplace component of engineering practice. Engineering educators have been studying ways to make teams more effective and inclusive. However, students' interpersonal interactions often create exclusionary experiences.

Purpose/Hypothesis: This study investigates how the team formation process and what kinds of teaming practices and behaviors promote inclusive team environments. We were sensitized to Tuckman and Jensen's (1977) revised theory of the five stages of teaming along with opportunity structures theory as frameworks to study how particular team interactions did or did not promote the inclusion of its members.

Design/Method: This interpretive multi-case study used team observations, classroom artifacts, and student interviews in a first-year engineering course to understand the experiences of three teams. The primary data source, student interviews, were analyzed to understand the individual and collective team experience. These results were triangulated with the other data sources to build three team descriptions and a cross-team comparison.

Results: Our findings indicate that the process of storming and norming in teams is an essential point in which social inclusion is built into teaming practices or not. While all teams, regardless of inclusive behaviors, were academically successful, the inclusive norms developed by some teams increased student learning and belonging.

Conclusions: The emphasis on teaming in engineering education has often focused on the effectiveness of teams for a final project. However, the process of teaming and how peers shape the engineering environment is just as important for student's belonging and persistence. The results of this work can provide strategies for supporting students' teaming processes to develop more inclusive teams.

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Teaming is well-studied in engineering education, management, and industrial and organizational psychology. Most studies have focused on team formation or team dynamics for outcomes such as student learning, team performance, or high-quality products (Asio et al., 2018; Baughman, Hassall, & Xu, 2019; Beigpourian, Luchini, Ohland, & Ferguson, 2019). Some have focused on particular psychological factors (e.g., psychological safety [Edmondson & Lei, 2014] or shared identity [Hinds & Mortensen, 2005], etc.). Other studies have examined how ingroup dynamics influence teaming experiences and outcomes. These studies indicate that individuals who hold stronger identities with subgroups of an organization, larger group, or society than the team as a whole may engage in biased behaviors toward non-subgroup members (Hewstone et al., 2002). This bias can result in negative stereotyping, constrained role assignments, and a lack of trust in teams (Flippen, 1999; Mackie et al., 1990). More positive teaming experiences occur when a shared group identity is developed (Tajfel, 2010). This finding seems relatively straightforward; however, the wider literature examining how diversity in team composition affects teaming is often mixed. Some studies indicate the positive effects of a diverse team, and others indicate challenges.

TEAMWORK IN ENGINEERING EDUCATION

Teamwork is essential to engineering practice; the ability to “function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives” is a key outcome of engineering programs (ABET, 2018, Outcome 5). Providing students with the opportunity to work with individuals with different experiences, backgrounds, and knowledge shapes collective learning and promotes innovation (Burt, 2004; Granovetter, 1973; Nielsen et al., 2017; Page, 2009; Strayhorn et al., 2014; Wang et al., 2019). Peer interactions shape the cultural environment within a classroom and significantly impact students’ engineering experiences, particularly in assigned teams (Joshi, 2014; Tonso, 2006).

Prior work on studying teams in engineering education has often focused on the practical considerations in forming and assessing teams, particularly for team outcomes (i.e., project quality or student learning gains). Oakley and colleagues (2004) provided a series of considerations on how teams are formed, how students and instructors set expectations for teaming, and how to support and evaluate teams. But more relevant to this work, several studies have been conducted on how the composition of teams (i.e., diversity) affects teaming experiences (Beigpourian & Ohland, 2019; Zhou et al., 2019). One study of multicultural teams found that students’ countries of origin significantly impacted team conflict and that the conflict was highest in teams with only one international student (Jimenez-Useche et al., 2015). A large body of research has focused on understanding the effects of gender on the composition of engineering teams (refer to Beigpourian & Ohland, 2019 for a review; Laeser et al., 2003). Lloyd and Szymakowski (2017) found that teams composed of more women had more discussions about teaming tasks and higher collaboration in problem-solving. However, research also documents that women in these teams were more often relegated to less engaged roles in technical design (Milovanovic & Gero, 2019; Natishan et al., 2000). In other work, women frequently believed that gender was a major issue in teams, commenting that men tended to be more aggressive in team processes, while men, in contrast, considered politics to be the big issue in teams involving women (Natishan et al., 2000). More recent research also supports these prior findings (Hirshfield & Koretsky, 2018; Wolfe et al., 2016). Less research has been conducted on how students at the intersections of race/ethnicity and gender function within engineering teams.

Like formation, assessment, and particularly peer ratings, are also enmeshed in the dynamics of race, gender, and other demographic variables. For example, one study quantitatively examined students’ self-ratings on teamwork at the intersection of race and gender and found that these self-ratings varied by both gender and race/ethnicity (Ro & Loya, 2015). Joshi (2014) emphasized that students evaluated teammates’ expertise subjectively to determine whose skills are necessary to complete their tasks and accomplish the team’s goals. Individuals who were

perceived as experts by other team members, regardless of their actual expertise, had greater influence in decision-making, received more opportunities to perform, and were more likely to be assigned informal leadership roles in teams (p. 203). These ratings often conform to gendered and racialized stereotypes (Baker et al., 2007; Biernat & Sesko, 2013). A recently funded National Science Foundation study (Grant No. 1936778) has begun to examine microaggressions and bias in teaming experiences to improve current peer assessment tools.

Even when best practices in team formation and assessment are followed, students note being pushed to the margins of engineering and into stereotypical roles based on gender and race/ethnicity rather than on the skills they bring to engineering (Cross & Paretti, 2020; Tonso, 2006). Tonso (2006) described how upper-division teams, in comparison to first-year teams, had “places in a campus hierarchy that privileged not only academic-science ways of life over those that design courses intended to promote, but also men’s ways of life over women’s” (p. 29). The process of learning engineering work in teams reinforced gendered ways of interacting in teams. These trends align with the broader teaming literature that indicates that simply forming diverse teams does not result in the ability for individuals to work effectively in these teams (Ely & Thomas, 2001; Van Der Zee et al., 2004). In engineering, students are often placed into teams in a course “where it is optimistically assumed that the experience of teamwork itself will make students better at working in teams” (Lancellotti & Boyd, 2008, pp. 244–245). Even when students report their teams are working well, evidence indicates that equitable teaming is not occurring (Cross & Paretti, 2020; Hirshfield, 2018), and when inequity occurs, students are often unwilling to act as allies to support their peers (Godwin et al., 2017).

Creating inclusive teaming environments in engineering is an essential step in not only challenging historical and cultural norms of exclusion but also to create spaces where all students benefit from learning from one another in their teams. Research indicates that diverse teams can have better products and learning outcomes (i.e., outperform) than homogeneous teams if they are managed well, and they can underperform homogeneous teams if managed poorly (Distefano & Maznevski, 2000; Maznevski & Distefano, 2000). Here, “managed” refers to how instructors and teammates handled conflict and interpersonal interactions to create cohesive and supportive environments. While the focus of these studies was not specifically on inclusion, these findings have implications for how individuals interact in teams, which can foster or hinder inclusion.

Studies focused specifically on experiences of inclusion in engineering teams indicate the complex nature of this topic. For example, Eddington et al. (2018) found that electrical and computing engineering students often had conflicting messages and experiences with diversity and inclusion in their engineering work and teams. The rigor of their program facilitated interactions between students, often discussed in terms of “survival.” These interactions often also created challenges, including communicating across cultures and backgrounds and difficulty coordinating projects, labs, and homework. Additionally, formal teaming experiences required additional effort to be successful and often reinforced negative stereotypes about an individual’s group identity or were completely ignored in favor of completing engineering work (emphasizing the cultural norm of social-technical dualism). These results are consistent with other work that found that after a first semester of working in assigned diverse teams, students were more aware of the benefits and challenges of diversity in teamwork but also less willing to engage in the efforts needed to create inclusive teaming environments (Godwin et al., 2017). Examining the complex facets of individual attitudes, team experiences, and cultural norms can provide insights into creating and supporting more inclusive teams in engineering education.

THE CONTEXT OF ENGINEERING CULTURE

Because diverse teams operate in the larger engineering context and not in isolation, we briefly highlight three dimensions of engineering culture linked to the historical and systemic exclusion of students in engineering contexts. We discuss three aspects of engineering culture that contextualize this work: 1) engineering culture as White and masculine; 2) engineering culture as

meritocratic; and 3) engineering culture as split between technical work and social work. We refer to specific groups when possible, and we use the term *minoritized when discussing multiple groups in tandem*. We acknowledge the ongoing conversation about the most inclusive ways to discuss race, ethnicity, and gender identity. We use this term because it emphasizes the persistent systemic engineering systems that oppress members of these groups. This oppression encompasses how the group is represented in engineering, what degree of access to resources it is granted, and how unequal access is rationalized. In using this term, we place the problematic practices squarely on systems rather than the individuals themselves. Next, we discuss the oppressive and exclusionary mechanisms of engineering.

In an engineering context that is White and masculine (Akpanudo et al., 2017; Pawley, 2017), the experiences of women, Black, African American, Latino/a/x, Indigenous, and disabled students, and those at the intersections of these identities are shaped and informed by their small numbers and engagement with peers who may reinforce cultural norms and create spaces of exclusion.

Second, engineering's culture of meritocracy emphasizes that skills and abilities are fair and available to all and that individuals are solely responsible for their societal position (Cech, 2013). The influence of this meritocracy negatively affects minoritized students by framing any issues they face in their engineering education as their fault, ignoring structural and cultural factors that can curtail an individual's success (Cech, 2013).

Finally, social-technical dualism, which frames engineering work as solely technical and thus apolitical and asocial (Faulkner, 2000) as well as objective, neutral, and bias-free (Cech, 2013) silences discussions about diversity and inclusion as relevant in engineering work (Bilimoria & Stewart, 2009; Cech & Waidzunus, 2009, 2011).

These three aspects of engineering culture create spaces that convey both explicit and implicit messages about who belongs in engineering and often cause minoritized students to conform to fit those cultural norms or work to shape spaces that include them (Benedict et al., 2020; Bilimoria & Stewart, 2009; Cech et al., 2017; Cech & Waidzunus, 2009; Hughes, 2017). This context emphasizes the need to study teaming experiences and understand how particular teaming practices and interpersonal interactions shape students' feelings of inclusion to provide engineering educators with ways to support students in diverse teams.

PURPOSE OF THE STUDY

While the above studies highlight the experiences of individual students, most studies do not highlight how the entire team contributes to inclusive or exclusive teaming experiences or discuss the particular challenges associated with forming and maintaining inclusive engineering teams. Additionally, studying teamwork is complex and challenging as it involves straddling the tension of understanding individuals and their lived experiences embedded in teams with shared experiences and identities. In this work, we explored how students' interpersonal interactions in diverse teams affected their experiences of inclusion. In this paper, we answer the following research questions:

1. How do students' attitudes about diversity and inclusion influence their teaming?
2. How do students experience working in diverse teams?
3. What aspects of team formation and development promote inclusive practices?

CONCEPTUAL FRAMEWORK

We were sensitized to two frameworks to understand the process of team development and inclusion: 1) a modified version of Tuckman and Jensens's (1977) team formation and development model and 2) opportunity structures for *social inclusion* within the engineering classroom. Together, these models describe both how students move through the process of team formation and engagement toward their academic outcomes and how the day-to-day interpersonal interactions

within teams create spaces of inclusion or exclusion in engineering. The sensitizing concepts helped us make sense of our study and findings, but we were also engaged in an inductive and interpretive process for sensemaking. We found these framings useful to understand the prior literature, study context, and framing of our work, but we also found them limited in their scope for describing the results of this study, which we describe in the Discussion section.

FORMATION AND DEVELOPMENT OF TEAMS

The Tuckman model posits that groups progress through various stages before they can be successful as a team: *Forming*, *Storming*, *Norming*, *Performing*, and *Adjourning*. Participants usually start in a state of high member uncertainty and search for common goals, work to develop group norms, and begin to exchange information. At this point, the team operates relatively independently, and while individuals may be motivated, they also are not well-informed about the issues of the team (Bonebright, 2010). The cultural and contextual setting of the team also informs early group formation. Individuals leverage prior experiences and work to maintain “normative standards” (i.e., reproduce acceptable cultural norms) to act in acceptable ways of being within the team (Tuckman & Jensen, 1977, p. 424).

The next stage, *Storming*, is one in which teams begin to figure out roles and build trust. Individuals learn about each person’s approaches to problem-solving and opinions. At this point, conflict may arise in the team as the team organization and hierarchy are established. The duration and intensity of this phase can significantly shape the team. Some teams skip this stage altogether, some may never emerge, and others may re-enter this phase if new challenges or disputes arise. In this stage, individuals are often resistant to deepening interpersonal relationships and exist in a state of positive and polite superficial interactions, which often avoids important but difficult conversations needed to foster inclusion.

In the *Norming* stage, individuals’ roles become established, and the team shares greater intimacy and shared goals. The team engages in interpersonal interactions, pursuing cohesion; however, members may be so focused on preventing conflict that they are reluctant to share controversial ideas. In the *Performing* stage, teams are motivated and knowledgeable enough to achieve high levels of success. If conflicts occur, they are healthy and channeled through the agreed-upon mechanisms within the team. It is important to note that many teams will revert to previous stages with changing circumstances, thus moving away from the ideals of the *Performing* stage. The last stage, *Adjourning*, comprises the finalization of team tasks with potential feelings of loss as the project concludes.

The Tuckman model is particularly useful because it describes a simplified and well-documented process for team formation and is flexible to include other models of student development. However, this framework alone does not examine how students who work in diverse teams interact or promote inclusive or exclusive behaviors. To understand how interpersonal interactions in diverse teams affect students’ experiences of inclusion, we combined this theory with a model of social inclusion and opportunity structures.

OPPORTUNITY STRUCTURES FOR SOCIAL INCLUSION IN TEAMS

In this work, we define social inclusion as the process of improving the terms on which individuals and groups take part in engineering and engineering work, particularly focusing on the inclusion of students who are often excluded and disadvantaged by engineering culture and systems on the basis of their identities (Allman, 2013). This definition is consistent with a larger description of social inclusion in education that focuses on access, participation, and success (Gidley et al., 2010). Social inclusion is created through the day-to-day interpersonal interactions that students have within educational structures, which are shaped by instructional experiences designed by educators. As such, we focus on interpersonal and instructional opportunity structures as key facets of teamwork from opportunity structures theory (Gray et al., 2018).

Interpersonal and instructional opportunity structures consist of practices and norms that support or hinder students' educational pursuits and engagement with the education system (Gray et al., 2018). Interpersonal opportunity structures are facilitated through the social ties actively created by faculty (Gray et al., 2018). Instructional opportunity structures engage students in ways that allow them to express their identities within the performance expectations of an academic setting (Gray et al., 2018); here, the expectations of engineering teams.

However, the enactment of interpersonal and instructional opportunity structures often systematically disadvantages women, Black, Latino/a/x, Indigenous, and disabled students, among other personal and social identity groups (Bancroft, 2018; Burt et al., 2018; Pawley, 2017; Pawley, 2019; Pawley et al., 2016; Starobin et al., 2010). For example, students from these groups are less likely to have faculty, mentors, advisors, or peers who share personal and social identities (Sowell et al., 2015). Peer discrimination, microaggressions, and exclusion isolates and punishes already oppressed student groups (Burt et al., 2018; Byars-Winston et al., 2010; McGee, 2016; Robnett, 2016; Wang & Degol, 2017). Finally, underserved students face unique challenges in conforming and participating in the university structure, including engineering teams.

As previously noted, interpersonal and instructional opportunity structures are fraught with challenges when trying to foster social inclusion. However, Tuckman and Jensen's (1977) team formation framework provides a structure with which to frame the discussion of inclusion in engineering teams at particular points in the team development process. The storming and norming stages of their teaming framework provide a suitable place within which to examine how the team's composition, interpersonal interactions, and socialization tendencies affected social inclusion.

When in the Storming phase, a team's perception of tasks while working on an engineering problem affects cooperation, collaboration, and communication (Gully et al., 1995, p. 502), all processes that can be moderated by team members' perceptions of social identities (Tuckman & Jensen, 1977). During the Norming stage, a team's interpersonal interactions culminate in the norms and behaviors they enact. Team members begin to accept the team environment and, in doing so, begin developing shared beliefs and cohesion within the team (Milliken et al., 2003; Tuckman, 1965). In this phase, inclusive teaming practices are established (or not). We use the above conceptualizations of team formation and social inclusion to frame the inclusivity of the three teams in our study.

METHODS

We investigated students' lived experiences in three teams within a first-year engineering course through a case study methodology. We collected multiple data streams, including questionnaire responses, CATME (Comprehensive Assessment of Team Member Effectiveness) team ratings (Ohland et al., 2012), ethnographic observations, and classroom artifacts, as well as conducted interviews to understand students' experiences in teams. In this paper, we emphasize the interview data as the primary source, as it provides students' interpretations of their experiences in their own words; however, we also bring in the other data streams to describe our team selection procedure and add richness to the context and interpretation of the teaming behaviors by the research team. To analyze the interviews, we used an *Interpretive Phenomenological Analysis* (IPA) annotating framework (Huff et al., 2018; Kirn et al., 2019; Smith, Flowers, & Larkin, 2009). This framework allowed for an understanding of the shared lived experiences of participants within the same team while maintaining the idiographic nuance of individuals. Then a cross-case analysis provided ways to understand how each team dynamic shaped inclusion within each team. The results of this work are three team descriptions of the process of social inclusion (or exclusion) and a cross-team comparison to understand better how students' interactions in teams shape their experiences.

CASE STUDY

Case studies are bounded by “spatial, temporal, organizational, or other factors” (Thomas, 2013, p. 512). In our work, we have chosen the team as a bound of the case and examined the interactions and dynamics within this group. Case studies also include rich descriptions of the context, individuals, themes, and issues that are present within the bounds of a case through multiple streams of data (Yazan, 2015). We used both quantitative and qualitative data sources to understand the setting, team composition, individual student attitudes, and behaviors within the team. Finally, case studies focus on real-life contextual conditions in which cases are situated, and the researcher has little control. We observed but did not intervene within these cases to better understand how inclusion occurred in a naturalistic setting.

The research team took an interpretive stance in this research; thus, we followed Stake’s (1995) approaches to case study. We position ourselves in this work as “gatherers of interpretations which require them to report their rendition or construction of the constructed reality or knowledge that they gather through their investigation” (Yazan, 2015, p. 137). We include positionality statements for the research team to describe our process of engagement within the study individually and collectively below. Additionally, Stake provides a flexible approach to case studies and acknowledges that the research questions, data collection procedures, and insights will evolve throughout the study as the researchers interact with and within the data. We have leveraged this flexibility to bring in IPA as an analytic method for the interview data in this study.

STUDY CONTEXT

We report findings from three first-year engineering (FYE) teams enrolled in a required first-year engineering course at a large, Midwestern research institution during the 2015–2016 academic year. The course focused on introducing students to the engineering design process through the use of three distinct engineering design projects. The large-enrollment class had multiple sections of approximately 120 engineering students. For each section, the teaching staff consisted of an instructor, a graduate teaching assistant, and four undergraduate peer teachers. The classroom was designed to encourage collaboration between learners with configurable seating.

Engineering design teams were created using CATME (Comprehensive Assessment of Team Member Effectiveness) Team Maker (Loughry et al., 2007, 2014) to create diverse engineering teams. Teams of four engineering students were constructed to avoid isolating students from minoritized groups within a team. CATME Team Maker was also configured to minimize scheduling issues and optimize team creation using each learner’s out-of-class schedules.

Diversity and inclusion were part of the core learning objectives in the course and were revisited by teaching staff throughout the semester through reflections, assignments, and in-class discussions. These objectives included but were not limited to evaluating the unique knowledge, skills, and abilities of each team member and developing strategies to support interactions between teammates and learn from one another. Additionally, the course curriculum emphasized teaming skills such as communication, organization of team structure and meetings, and role rotation. Throughout the semester, team members offered constructive feedback and rated their teammate’s contributions. Team evaluations were available to the teaching team and provided information to detect teaming conflicts throughout the semester.

PARTICIPANT SELECTION

Teams were selected for this study based on their responses to quantitative questionnaires that examined students’ multicultural personalities, perceptions of diversity, and demographics (refer to Godwin et al., 2017, for more details about these measures). Data were then examined to identify teams whose members showed maximum variation across each of these factors, as well as teams that included women, Black, Latino/a/x, Indigenous, and disabled students. From the resulting list of 14 teams, we randomly selected one team per section for recruitment. Of the

teams identified, three teams agreed to participate in observations of their teaming throughout the course and had multiple individuals participate in follow-up interviews. This study focuses on 11 students across three teams: *Canis*, *Melinae*, and *Apis* (the researchers assigned pseudonyms based on team behaviors). Participants selected their individual pseudonyms in the interviews.

DATA COLLECTION

The primary sources of data for this study are two 60-90 minute interviews with each team member after the conclusion of the course and observations of teams. The first interview asked participants about their background experiences prior to college, their identities and conceptualizations of diversity and inclusion, and how those concepts connected to their engineering work. The second interview focused on their teaming experiences broadly, their engineering teaming experiences in the FYE course, and the ways in which their responses from the first interview were connected to their teaming experience in FYE.

In addition to the interview data, multiple observations of teams doing design work in class were conducted. These observations included recorded audio and field notes. Additionally, the design artifacts from students' work were collected. We also collected responses to a questionnaire about students' attitudes about diversity and teaming, engineering identity, and motivation at the beginning and end of the semester, as well as used the CATME Peer and Self Assessment multiple times during the semester. In both the making and handling of the data, validation was considered across multiple dimensions, consistent with Walther et al. (2013).

ANALYSIS

All interviews were recorded and professionally transcribed. After transcription, interview transcripts were cleaned to ensure accuracy and anonymized by a member of the research team who listened to the audio alongside this process. Listening to the audio also allowed the researchers to familiarize themselves with the participants' voices. This familiarity helped ensure participants' voices were prioritized during subsequent analytic phases and aligns with communicative validity from Walther et al. (2013).

A modified IPA annotating framework was used to analyze the data in two phases: at the individual and then team level (Kim et al., 2019). This approach was chosen to provide in-depth descriptions and interpretations of the research participants' shared lived experiences of work in diverse teams and how that phenomenon has influenced the research participants. For the first phase of analysis, the author team individually analyzed each participant. Subsequently, the first author synthesized the findings into team-level descriptions and drew conclusions across participant interviews.

The results of this work are rich and complex descriptions that preserve the idiosyncratic nature of an individual's experiences (Alase, 2017). The interviews were coded in three passes—descriptive, linguistic, and interpretive (Huff et al., 2014). Descriptive comments focused on the significant features in the transcript, such as key phrases, explanations, descriptions, and emotional responses. The linguistic comments enhanced the previous pass to examine how the content and meaning were presented by participants. Considering the process of communication (i.e., “how”) alongside the content (i.e., “what”) allowed the researchers to understand the meaning of the participant's words. This pass focused on pronoun use, word choice and construction, repetition, and metaphor use. Finally, the interpretive pass interrogated the meaning of the descriptive and linguistic comments. This pass supported the development of themes from the data.

The resulting themes compiled at the team level were compared across each team to create superordinate themes that explained the essence of the lived experience of working in diverse teams. Themes generated at all levels were checked against other sources of data generated for the larger project. These sources include but are not limited to team reflections, CATME scores, ethnographic video record observations, and researchers' field notes. We used these additional sources of data to better understand how the individual student and the team were situated within the context of the course. Observations, in particular, provided additional indications of participants' tone, gestures, and body language during the events described in the interviews.

When possible, analyst inferences based on observation data were clarified with participants during interviews. The CATME scores and comments were used to understand students' in-the-moment feelings of team cohesion, effectiveness, and emotion during the course.

Throughout the analysis, the researchers engaged in memoing and whole team discussions. This memoing process aided in recognizing and describing prior knowledge and experiences related to diversity, inclusion, and teaming and centered interpretations exclusively on participants' descriptions, which adds evidence for procedural validation as well as process reliability. Additionally, the researchers met twice a week to discuss what was emerging from the data, the trends and stories of each participant, and potential codes that were emerging. This process allowed for the examination of consistency in the coding team but still preserved the idiographic nature of the data presented by each participant (Smith, Flowers, & Larkin, 2009). This approach supported theoretical validation to ensure findings were consistent with the conceptual framework and social reality under consideration (Walther et al., 2013).

PARTICIPANTS

The participants in this study consented to and completed all the data collection procedures. Their pseudonyms, team membership, and self-described identities are shown in Tables 1 through 3.

TEAM NAME	PSEUDONYM	SELF-DESCRIBED DEMOGRAPHICS
Canis	Ezekiel	- Straight African American and Native American man - From a diverse religious, geographic, social and political background - Had ADHD and test anxiety - Had experiences in K-12 that exposed him to engineering
	Stanley	- Japanese international student - Man - Attended four years of school in London - Attended an international school (taught in English) in Japan
	Peter	- Second-generation Chinese American man - Grew up in New York - Lived in South Carolina - Described becoming a minority after moving to South Carolina
	Xander	- White man - Grew up in the Midwest - Has family on either coast of the United States - Had experiences in K-12 that exposed him to engineering

Table 1 Participant information for team Canis from questionnaires and interviews, including pseudonyms and self-described demographics.

TEAM NAME	PSEUDONYM	SELF-DESCRIBED DEMOGRAPHICS
Apis	Icarus	- White man - From Indiana - Moved around during primary education as a U.S. military family - From a conservative family - Seeks financial security through a college education.
	Mari	- Half Japanese, half Polish woman - From Illinois - Described family as well-off - Attended STEM-focused high school
	Milton	* Not interviewed - Chinese international student - Man
	Sarah	- White woman - Born in New York - Moved to Texas when young - Attended White minority high school - Well traveled

Table 2 Participant information for team Apis from questionnaires and interviews, including pseudonyms and self-described demographics.

TEAM NAME	PSEUDONYM	SELF-DESCRIBED DEMOGRAPHICS
Melinae	Al	- Indian immigrant who came to the U.S. when young - Man - From Alabama - From an upper-middle-class family with parents with advanced degrees - Well traveled - Attended boarding school
	Barney	- International student from India - Man - From a self-described “joint family” [house shared between extended families]. - Well traveled - Aspired to own his own automotive business
	Stewart	- White man - From Massachusetts - Attended all-men’s Catholic high school - Parents had advanced degrees - Had an adopted sister from South Korea - Diverse high school friend group - Never traveled outside the United States - Overweight and bullied at a young age, lost weight by getting into sports (Rugby)
	Thomas	* Only completed the first interview - White man - From New York - Well-versed in technical work

Table 3 Participant information for team Melinae from questionnaires and interviews, including pseudonyms and self-described demographics.

POSITIONALITY

Positionality was considered at multiple phases in the research process, including how it influenced the focus of this research, the relationship with participants both in making the data and interpreting it, and the research quality (Secules et al., 2020). Since the work was conducted as a team, first, the research team engaged in a group positionality discussion to highlight the epistemologies and beliefs that we brought to bear on the data and to make these beliefs explicit to other research team members. Then, as the data were analyzed, we regularly revisited discussions of our positionality to consider how it influenced the claims we made. In this paper, we focus our discussion on the positionalities of the three authors who contributed heavily to analysis and writing and then shift our focus to highlight the positionalities of the research team. All members of the author team were offered the opportunity to contribute positionality statements, but only the three primary researchers provided them.

Team Positionality

The project was designed to explore students’ attitudes about diversity as a result of working on engineering teams. While this project examined a broader perception of diversity than some other work in engineering, it did not examine specific attitudes about diversity that have risen to national consciousness after 2020. At the time of conducting the work, 2015–2019, the research team had limited working knowledge of anti-racist practices and did not incorporate specific aspects of this framing into the work. Instead, we used existing conceptualizations of diversity, equity, and inclusion from multiculturalism practices and from our previous work examining students’ attitudes in engineering. We provide this context so that the decisions made in time, place, and knowledge are explicit to the reader and can be evaluated accordingly. With this framing in mind, this work provides an exploration of the ways that inclusion is perceived in engineering teams.

Researchers’ Positionalities

Rodríguez-Simmonds is a gay, Latino-identifying computer engineer pursuing his Ph.D. in engineering education. He largely contributed to the creation of the storyline of this research in addition to analyzing various participants’ interviews. As a gay Latino immigrant ADHD-having non-traditional undergraduate engineering student, he resonated with Ezekiel’s story. As a gay

man often castigated for behaving “effeminately” and having grown up very close with his mom, grandmothers, and aunt, he was sensitive to Mari and Sarah’s stories. His positionality affected the way he responded to and understood what he reported in his analysis. These sensitivities were discussed as they are related to certain identities because he felt offended and angry at times with some of the work he and his co-authors wrote for this publication. As a cisgender male-identifying individual, he also saw the limitations of a focus solely on gender that occurred within the teams. This result caused him to reflect on his behavior as a man in engineering. Throughout this research, he often felt compelled to recognize, understand, and report to the research group (and himself) what he felt his tribe of men was doing by socializing in certain ways. He felt compelled to expose and correct small moments during socialization that privilege men in engineering, all the while being a beneficiary of some of these privileges.

Allison Godwin is a White woman, engineering education researcher, and faculty member in chemical and biomolecular engineering. Her work has focused on how the culture and process of engineering education shape the ways students see themselves as the kind of people that can do engineering. As a cisgender woman in engineering, some of the stories from these observations and interviews were similar to her own experiences, and as an instructor in the FYE program, she felt a responsibility to these participants and her students to better understand how team dynamics impact learner identities and experiences of inclusion in the classroom. Her hope is that the results of this work can better inform her own practice.

Kirn is a gay, White man faculty member in engineering education. His experiences with passing and covering in engineering influence his goals to create just, equitable, and inclusive engineering environments. His work explores the ways undergraduate and graduate levels of engineering education serve to marginalize students and create homogenized systems of beliefs that reproduce existing systems of education and work. Particularly, his work centers the voices of students to understand the ways an ecosystem shapes students’ actions. This work connects to his broader work by making clear how common experiences like teaming can serve to include or further marginalize students.

RESULTS

Our results provide rich descriptions of the experiences of students in three teams. We present results for each team at two levels: 1) the description of how the team developed and normed and 2) how this teaming experience affected feelings of inclusion for individuals in the team.

CANIS TEAM: THE LEADERS AND THE REST OF THE PACK

The Canis team included Ezekiel, Peter, Stanley, and Xander. This team skipped much of the norming and storming parts of the team development process and did not explicitly discuss diversity or inclusion as a part of their team development. We found three superordinate themes about individuals’ shared lived experiences in this team: getting work done, professionalism, and a focus on superficial commonalities. The team approached their engineering work using a divide-and-conquer strategy, functioning together only when necessary. They established a hierarchy of roles based on technical expertise and operated as independently as possible (i.e., a “lone wolf” approach, hence the name Canis). This approach has significant negative impacts on some team members’ experiences of inclusion, particularly Ezekiel.

Getting work done

Stanley took on a leadership role within the team along with Peter and assigned work to various teammates. He focused on turning in work “you feel good about or feel that you can honestly say that you put 100% into...something that I can be proud of at the end of the day.” Stanley did not believe that diversity played a strong role in how a team interacted. He categorized teammates based on his perception of their work quality, citing that individuals that do worse work may be “lazy” or “just careless.” In doing so, he undervalued Ezekiel and Xander’s approaches and contributions.

We observed these attitudes in practice within the classroom. At the beginning of a design task, Stanley and the team read through the instructions. Before the team could even finish reading, he had already started assigning specific tasks and roles to each team member. Ezekiel tried to provide some input on the process but was ignored. During this interaction, Peter started doing the work assigned by Stanley while Xander observed the interaction between Ezekiel and Stanley. Xander felt Ezekiel thought “more creatively,” and he reflected on the dynamic within the team that “Peter and Stanley wanted to think more analytically with numbers and through design processes.”

Ezekiel was often assigned the responsibility of writing or checking others’ work, and Xander was given the “easy tasks.” This reflection was supported by multiple team members’ interviews and our observation of the team. Xander was often given the job of looking up a fact or finding a citation while Ezekiel finalized submissions and read through them one last time for both writing and mathematical errors. However, Stanley and Peter were the only members of the team that submitted assignments because they wanted to ensure the work matched their standards of quality.

Professionalism does not include getting to know teammates

During the forming stage, the team did not focus on learning more about one another or discussing how their backgrounds and approaches to problem-solving may challenge or strengthen their teams. Peter said, “We definitely weren’t familiar with each other. We didn’t really hang out after class or anything, but we definitely knew how to interact with the group.” He felt his minimal familiarity with his team was sufficient to complete his engineering work. Throughout the course, the team was encouraged to have deeper discussions about their backgrounds and the impact on teaming as a part of the curriculum, but the teammates did not see this task as relevant to their engineering work. Several team members framed this distancing in terms of “professionalism.” For example, Peter used this idea to describe that having personal conversations in an engineering class was not professional. He emphasized that inclusion was “respect [for] each other’s ideas and opinion[s]” with no other considerations. However, he also shared that he did not feel he could bring up concerns or criticisms to his team. Xander emphasized,

It [diversity] didn’t really make that much of a difference to me at all because we were all contributing ideas, and I guess it’s more of the upbringing of the person that tells you how intelligent they are more than their ethnicity.

In our observations, we noted little socializing within the team. Almost all of the team discussions focused on task assignments, checking in on task-related efforts, and getting work done. Even typical discussions about plans before or after class, other course exams or tasks, or personal details were not noted in our field notes.

Focus on superficial commonalities

This team was diverse in national origin, ethnicity, geographic hometowns, religion, and disability. However, this team focused on common aspects of their experiences and deemphasized diversity to accomplish engineering tasks. As an all-men team, most team members discussed a shared background of gender and a love of sports as a sufficient basis of commonality. Stanley shared,

Obviously, I don’t have anything against women or girls; I guess it’s just easier for me to work with the same gender. I can be more laid back; when we do go off track and talk about other stuff, it’s easier to relate to each other just because maybe something in sports or TV shows or something like that.

Peter discussed this team composition as well,

Being an all-guys group definitely was easier for our part just because I feel like we knew better what each member wanted to do, and also, it was very easy to tell the work habits, I guess, of each group or each team member.

Being “laid back” and not worrying about what or how they said things to one another created a teaming environment in which perceptions of teammates were unquestioned and static. It also created an environment where inclusion, particularly in the norming and storming phases of team development, was overlooked and not prioritized or considered an important aspect of teaming or engineering work. Despite the team’s diverse composition (“There was a guy from Tokyo, and Ezekiel was African American, and Peter was from South Carolina”), Xander felt his team was not all that different: “I guess, whatever, I guess it’s not really that different. I didn’t really notice that much of a difference.” Xander felt his team “was fine. We’re all guys, so we kind of think the same.” Xander repeatedly said his “team was perfect” and would “take [his] team again if [he] could” because they completed work efficiently and quickly. The team converged on a common narrative that diversity provided a means of accomplishing a task in a way that was better than what could be accomplished individually.

Impact on inclusion

Ezekiel had the most negative experience within this team. While he enjoyed working in his team, he also wanted to work in a diverse team. The team’s orientation to working together, which centered on getting quality work done, professionalism, and leveraging their gendered similarities to forego intimate interpersonal interactions, left Ezekiel frustrated. He said,

I got put with straight guys. Of which two of the same ethnicity. I got stuck with the same people, the same non-diverse team. I didn’t get to meet anyone else new. I didn’t get a new perspective on anything, really. It was more like; I’m taking this class to get a grade because First Year Engineering says I have to.

Ezekiel coped with the team’s norm of getting the “highest grade [they] needed in class ” by compromising his learning:

I had no idea how to do the math for it. I was just going to brute force it. Peter actually knew what he was doing. There is the difference in approach in that. That is what led us to, “Peter’s going to handle the math, Ezekiel, you handle the writing part.” I was saying, “Explain to me how this works. I’m going to write it down and make sure that it all is formatted correctly, so we get the good grade. I’m going to figure out how to do this on my own at some later point, so I’m doing well with the practical. For now, we need to get the good grade, so let’s figure out how we’re going to get that.” Compromising, we ended up getting a good grade, so I was, like, “Okay, whatever.”

Ezekiel felt that he was not getting the cohesive team experience and opportunity to learn in his team that the course promised. While he ultimately was successful in the course, he framed the process of working in his team as an experience he had to “endure” rather than something that was positive. As the team continued to prioritize the accomplishment of goals over integrating diverse skill sets and valuing differences, an environment was created where exclusionary actions occurred.

The team treated conversations about diversity as either unimportant (or unprofessional) or believed they had satisfied a checklist requirement for the course. We observed no discussions related to different perspectives, backgrounds, or diversity and inclusion, as emphasized in the course. As part of the team formation process, team Canis immediately jumped to the performing stage to work together efficiently, but this lack of team development had negative consequences. Team Canis’s ability to do work in a divide-and-conquer format further reduced the number of interpersonal interactions between team members, limiting connections with one another by simply focusing on the course materials and accomplishing the assigned tasks (Rodríguez-Simmonds et al., 2017). This approach to teaming reduced interpersonal interactions, limited the building of deeper trust within the team, and constrained shared development in the norming stage of the team, leading to less rich and inclusive teaming experiences.

Team Melinae was also a team of all men comprised of four students: Al, Barney, Stewart, and Thomas. The team was composed of both domestic (both in-state and out-of-state) and international team members, as well as members from varied socioeconomic classes. Thomas, the team's most technically skilled individual, unexpectedly left the team towards the end of the semester and was not interviewed. Al and Barney completed both interviews, and Stewart completed only the first interview. Due to attrition, much of this team's information about team development, roles, and inclusive behaviors was based on Al and Barney's interviews. Thomas's abrupt exit from the team had significant consequences for the team's development and redevelopment, as well as the creation of inclusive teaming practices. Like other teams, this group had a strong commitment to high-quality work and getting a good grade. This team engaged in not only individual work strategies but also collaborative efforts to synthesize work across team members. The resulting team development and practices created a somewhat inclusive environment. Their name was chosen for their badger-like blend of individualistic and collaborative behavior (*Melinae*). We found three superordinate themes: direct communication associated with masculinity, openness is essential to teamwork, and disruption and reflection in non-linear team development.

Direct communication associated with masculinity

The team members we interviewed cited that masculinity was a salient identity in their norming process. Both Al and Barney discussed how being in a group of all men fostered a working environment in which conflict was minimized and assertive and more effective team interactions were acceptable. He compared his team to a neighboring team of three women and one man and said that his team was less "timid" and "flaky" and more "confident." He felt the individuals in his team were "comfortable enough to speak out and say, 'I don't really agree with that and here's why'...in a stereotypical female, maybe [a disagreement or opinion] doesn't come out." Al said, "it [being an all-male team] helped our solution, but it definitely let everyone know how everyone felt. I think that was important because there was never any awkwardness or tension between any of us." To Al, the lack of timidity made the team less tense and awkward, more comfortable and open, and more effective. His teammate, Barney, also agreed that their team was a place where everyone could express and critique ideas.

In our observations of these students, we noted a strong camaraderie centered on typical masculinity (Akpanudo et al., 2017). The team regularly teased and joked with one another about sports, parties, and other social activities. One of our observers noted Stewart's "frat boy" style of dress and tendency to make jokes that straddled a line of teasing and appropriateness when working with his teammates. Barney and Al often laughed at these jokes but rarely initiated them on the team. The team regularly split work among the four team members, created a plan, and then worked with little communication until the end of the effort. But, when there was a deadline or other pressing issue, the team regularly offered help to one another. Members regularly stood up and physically moved to the other side of the table to share a screen or talk through the issue another team member was facing.

The interviewees discussed their shared masculinity as valuable to their socialization in forming and norming but did not see gender or diversity more broadly as related to their engineering work. We note that these perspectives perpetuated gendered engineering norms, and while the team composition supported these team members' experiences, this perspective does not reflect inclusive team practices. While norming and storming were seemingly eased by virtue of a shared team gender, this team also let their shared gender shape how they thought about diversity within teamwork. In contrast to members of team Canis, this team considered getting to know one another and understanding their relative strengths as essential for teaming rather than creating boundaries to separate the "professional" work-related domain from their larger lives. This approach to norming provided opportunities for teammates to share some of their experiences and backgrounds and also engage in team formation that largely ignored the importance of diversity in their engineering practice.

Openness is essential to teamwork

When asked about how the composition of the team influenced the team dynamics and outcomes, the team members discussed openness with one another as an essential aspect of successful teamwork. Both Al and Barney specifically discussed the importance of openness in considering diversity and having an inclusive and effective team. Barney described that being open to “different people from different cultures and backgrounds” and creating a “judgment-free zone” were essential aspects of teaming. Barney and Al described the importance of openness in their idea generation. “When you’re working with a team, we get more—we identify more problems that are solutions, and then we correct that, which makes it a much better solution,” Barney shared. In our team observations, we noted a team planning process where everyone had input, tasks were broken up and assigned to individuals, and ongoing updates and conversations were part of the Melinae process. The team operated on tasks more similarly to the Canis team, but, like team Apis, described later, they also worked on valuing each other’s ideas and input in their teaming process.

While this openness was a positive aspect of this team, this orientation largely ignored the reality of power and privilege for members of dominant groups within engineering. For example, Stewart mentioned religion, socioeconomic status, and geographic origin as facets of diversity. He described how he grew up with some but minimal interactions with people from various races, religions, socioeconomic statuses, and geographic origins. He gave the example of his adopted sister from Korea and said he would “[forget] that she’s Asian. She’s just like my little sister.” His quote illustrates Stewart’s attitude that it is sufficient to find similarities among people with whom he worked. None of the students in this team discussed how particular racial, ethnic, gender, or other aspects of identity could affect a person’s socially created opportunities.

Disruption and reflection in non-linear team development

In contrast to other teams in this study, this team’s formation did not follow the typical Tuckman and Jensen (1977) team formation and development model. Team formation was interrupted several times in the semester; however, these disruptions forced the team to reflect on their practices and adjust their behaviors, ultimately leading to more inclusive team norms.

A significant factor contributing to the re-development of team norms, roles, and work distribution, was Thomas’s “completely unexpected” departure two-thirds of the way through the semester. Barney and his team were perplexed, “Thomas just sent us the text and was like, ‘Hey, I am done.’ I don’t know why. Nobody really knows why. He had an A [...] That was just kind of out of the blue.” At that point, the team had developed teamwork norms and roles around Thomas and Barney’s high-quality work.

Thomas’s departure made them reflect on the norms and roles they had set at the beginning of the team development process and forced them to revisit the early teaming stages—re-forming, re-storming, and re-norming out of necessity. We noted Thomas’s central role in directing the team and delivering high-quality work during our observations. During our last observation, we noted that Thomas was absent, and the team seemed to be working to figure out new roles. After that observation, we asked where Thomas was and found out that he had left engineering. The team’s perception of task interdependence (Brass, 1981) increased after they were down a team member. Concurrently, Barney did not submit an assignment on time, further inducing a re-examination of the team’s performance.

Barney described the disruption, “When Thomas was there, I think the work was much more equally distributed. After that, I think more work came towards me, but then we just made sure when we sit down together, everyone’s working.” In addition to teamwork, the team’s social balance was upended when Thomas left. The rebalancing of team responsibilities required greater communication and collaboration across the team, as well as team members actively initiating interactions to combat isolation. Al elaborated on the initial awkwardness and isolation he felt when Thomas left:

Looking back, this probably happened once where I had to say, hey guys, like, what are you talking about? Then it was like, oh, I couldn't. Because they started talking and I am sitting there. Usually, I would talk to Thomas, and there's no one there.

The disruption to their established team norms forced circumstantial trust, causing them to examine and redefine established boundaries and roles. As they stormed again, they discussed interpersonal issues and re-challenged pre-established psychological security (Maslow et al., 1945) norms in the team. Driven by their objective to do good work, the need to work together more tightly, along with their propensity to value one another's diverse attributes, the team adapted their norms to better reflect their new three-team-member dynamic. The smaller, more intimate team was still committed to completing assignments well. To this end, they communicated more frequently, actively fighting the tendency for team members to become isolated and adaptively compensating for one another using their newly cultivated understanding of one another.

Impact on inclusion

Throughout the semester, the team's iterative formation process resulted in a working environment that increasingly supported each member's strengths and promoted collaborative learning. Increases in inclusive teaming practices, the interrelatedness of tasks, collaborative teaming behaviors, and circumstantial trust and intimacy-building added up to create a more inclusive team. Members of this team learned more about *how* their team members worked because they collaborated significantly on tasks, had more intimate understandings of one another, and worked more closely after Thomas suddenly departed.

The team always prioritized task completion, dividing tasks based on individual skills and interests. However, to divide tasks, they learned which task each team member felt most comfortable completing and then assigned responsibilities. Al said, "I guess it just, like, we figured out by the time we were working, collaborating, it was like, oh, somebody has a good grasp of this. They should probably handle this section of it [...] It was never formal[ly assigned] that way. I think it just depended on strengths and how that evolved." Al continued, "Instead of somebody builds this piece, another person builds the next piece, and we sort of build upon each other; this was more like four people working in unison throughout the whole thing." Stewart concurred, saying, "We started with the reasoning, we discussed all the reasons, and then they start[ed] writing it out." Barney added, "[Thomas] would do the Excel, and after that's done, Thomas would sit down to finalize ... Just to make it appropriate for technical presentation, and I would proofread the document and make any technical changes." As compared to team Canis, this team worked more tightly, invoked trust, and shared interdependent tasks as they worked together.

The team cohesiveness was increased by informal goofing around in class. Al felt his team

was like, almost a more playful nature. It was less, at the beginning [of the semester], obviously, [when] we knew there was an assignment coming up. It was like less—task-oriented. It was like, create something or like create something new.

The development of deeper relationships that manifested in informal interpersonal interactions helped team Melinae build trust and successful team outcomes. It was this focus on getting to know one another, working in unison, and valuing each other's contributions that shaped inclusion. This focus did not happen immediately but was shaped by the commitment to openness and the value of diversity as well as the non-linear team development process.

For example, Barney increasingly felt it was less of a waste of time to talk about things other than engineering (as long as the work was still "eventually finish[ed] in time"). At the start of the semester, Barney did not appreciate losing time idly chatting, saying, "Yeah, we did waste a lot of time when we used to meet because we'd start out with sports and all those conversations, but then we'd eventually finish in time." For Barney, finishing efficiently was important. However, he also recognized that his belongingness was bolstered by informal discussions. Barney "catching up" with teammates illustrated how his approach to teamwork and the importance of considering

inclusion shifted over the semester. He increasingly valued norms that included interpersonal interactions in addition to high-quality work. He said he belonged in his team because they “didn’t just talk about engineering whenever we’d meet ... We would do our work as well as talk about what’s happening in sports,” then spend time “catching up [on our engineering work].” Reflecting back, Barney said, “If we see each other on the road or just passing by, we have, like, a minute or two of just catching up.”

This team exhibited some aspects of considering diversity in their teaming process; however, the orientation of this team to treating individuals as equally as possible, without regard to race, culture, or ethnicity, created a team environment that did not align with the model of social inclusion. This approach to teaming tends to individualize conflict and key issues that are direct results of systemic bias (Tarca, 2005). In our observations, we noted issues that cropped up, including visible frustration with one another, and at times, these specific issues were addressed openly. However, the team’s focus on jocularity and masculinity created a team environment where these conversations could only be so deep and go so far in examining the overall experience and contributions of each member to the team dynamic. This team is an example of many in the larger team study that began to consider how diversity is important in engineering teamwork but had not considered larger issues of power, privilege, and their actions within their teams.

APIS TEAM: TO ACHIEVE SOMETHING GREATER, YOU HAVE TO WORK TOGETHER

Team Apis consisted of four individuals: Mari, Icarus, Sarah, and Milton. Of the four team members, Milton did not consent to be interviewed during this project. The three team members interviewed were diverse in terms of ethnicity, race, gender, and domestic and international status. We found two key superordinate themes within this group: Deep engagement with differences within the norming team development phase and consensus building and inclusive actions even during conflict. They focused on deep-level aspects of diversity within the team early on in the norming team-development process. Perhaps, the lack of visibly similar identities (such as gender in the Canis team) encouraged the Apis team to examine deeper similarities and synergies among teammates. Much like a family of honey bees (*Apis*), this team developed norms of frequent communication and closely understood one another as they cohesively worked together.

During observations, we noticed several moments of informal interactions where team members collegially joked with one another and would, at times, become distracted. Instead of considering distraction a negative team experience, members of the Apis team considered these moments a way to get to know one another and create informal open environments where ideas could be brought up and criticized with little hesitation.

Deep engagement with differences within the norming team development phase

During the team formation stage, each member brought in previous experiences and understandings of diversity, reflecting their prior experiences, and emphasizing the most salient factors in their own lives. The team explicitly discussed the strengths and perspectives each of them brought during their teaming development. They considered this discussion ongoing and key to the team’s development. The team framed their differences as assets and openly discussed potential conflicts based on these differences. Because of this approach, they set inclusive norms early on in their teaming processes. Icarus discussed that “being accepting is one of those things that got drilled into my head as a child [...] everybody has something that they can offer, and everybody is important in their own way, even if it’s not evident at first.” Sarah elaborated:

I think the fact that we were all very different people. We all brought our different experiences and knowledge, and skills that we learned in the past together. I think we were a well-rounded team. We agreed and disagreed, but we always found a way to agree eventually.

As the team transitioned to the storming phase, they openly discussed interpersonal issues and conflicts that arose. Mari, who saw herself as having a good grasp of Excel and engineering in general, respected Milton and Icarus for their more specialized knowledge of some programs. However, she often argued with Icarus about his approach and methods, worrying that he over-complicated tasks:

I have a little bit of anxiety about things like that. I'm like, "Time is very precious. Why are we wasting our time doing this? Why would we do that?" Icarus was like, "No, trust me. I can try to get it done. If we don't get it done, there's no harm because Milton's the only one who can work on the other one anyways. We already have the data that we need, so let me try it." I was like, "Okay."

All team members described feeling comfortable, interacting honestly, voicing opposition, and navigating tense team discussions as a part of the team's success. Sarah stated, "We all shared our ideas together and then came up with a solution, and our solution always incorporated each other's ideas." Icarus reinforced this idea by saying, "we thought about where they're [his teammates are] coming from [when conflict happened]." Teammates noted that this deeper level of trust and openness required really getting to know one another and giving each other the "benefit of the doubt." In contrast to team Canis, each team member discussed more frequent, casual interactions inside and outside the classroom during the performance stage. For example, Mari shared,

We always worked at horrible hours. We'd be like, "Let's start working at six o'clock." Everyone would get hungry twenty minutes in. We'd go, we'd eat, we'd come back. Being forced to have conversation. It's not like we were, "Oh, we have to sit together." Well, we went to dinner to the same place, we all know each other. That's more comfortable than sitting by yourself or with a stranger. We would sit together, and when you sit with someone you talk to them. It just happened.

Impact on inclusion

The openness cultivated during the norming and storming phases of team development translated into collaborative, adaptive team norms that promoted all members feeling included. Multiple team members discussed trust as a key aspect of the team's success. Mari shared,

Our ability as a team to really trust each other was a huge benefactor in that moment. If we hadn't been able to trust each other, there would have been a fight, and then someone wouldn't have been able to accomplish something because we wouldn't be getting along...the classic feng shui, like yin/yang, balance of the see-saw. If I hadn't had those team members, I wouldn't have gotten the grade I did. Sometimes if I wasn't strong in something, I would not get a good grade, but I could rely on them or my friends who were in engineering to help me with the homework assignment, help me with whatever was going on if I needed it.

Similar to the Canis team, this team also had a key outcome expectation of doing well in their engineering work. However, the approach to teamwork and engagement with norming and storming during Apis's team development process manifested in a trusting and closely related teaming experience. Teammates would often ask one another for help and work collaboratively to solve problems. In our observation, we saw teammates regularly leaving their chairs and computers to huddle around one screen or notepad as they ideated. Our field notes specifically noted an "invasion of personal space" as an example of their closeness to ensure all team members were included in the process.

The orientation to diversity as valuable to the team and willingness to delve deeply into each team member's strengths and weaknesses created an environment in which each team member found a way of positively contributing to the team based on the complementary skills they had

collectively identified. Mari described working to be “super considerate” and “[taking] on that whole leadership role that’s also idealistic where everyone feels welcome, everyone is listened to, everyone does something that they enjoy doing, not just what they’re good at.”

The team developed norms that emphasized the contributions that each individual brought to the team based on their strengths and perspectives. For example, Sarah’s organizational, interpersonal, and project management skills led to her being considered the “group mama” by everyone on the team. Mari said, “Sarah made sure everyone was doing everything correctly, even if it wasn’t project-related material, but just in general making sure things were on time and such.” Mari elaborated, “Icarus would be running around being crazy and funny and loud, and Sarah would be like, ‘I’m going to go full mom on you right now. You need to settle down.’” The vulnerability and openness they expressed during the storming phase were evidenced by the playfulness and informal dynamic within the team during observations and our individual follow-up interviews. We note that the discourse of “mom” and “dad” was typical parlance in social media at the time of data collection. These terms were used to jokingly refer to anyone who took on an authority role in a group setting. The term was used by Sarah about herself and others in the team about her and Icarus’s roles. Apis team members’ increased understanding and respect towards one another increased the trust felt by team members, further propelling the idea that working together helped them achieve something greater.

DISCUSSION

Our results describe the ways student interactions within the teaming process created different experiences of inclusion for individuals and students collectively. Teams were selected to maximize variation in composition and student attitudes within the team. As such, we found varying approaches to how each of these teams moved through their teaming stages from our sensitizing framework and their subsequent actions toward equity and inclusion. Our results show that deep socialization in the storming and norming phases led to more inclusive practices in teams. They also emphasized that students must learn how to embrace conflict as a part of team development and engage in that conflict in productive ways to support inclusive practices.

ENGAGEMENT WITH DEI CONCEPTS IN TEAM DEVELOPMENT IS ESSENTIAL FOR INCLUSIVE PRACTICES

The different compositions of teams affected how students considered DEI. For example, team Canis collectively focused on their team composition of all men. This focus emphasized the similarity of the individual members of the team rather than the differences in race, country of origin, and experiences prior to university. Additionally, three of the four teammates, all except for Ezekiel, emphasized completing course tasks as quickly and efficiently as possible rather than engaging in learning from one another. This approach aligns with ideological framings of race and racism that work to ignore societally driven differences in treatment—that is, that groups of people should not matter and that all should be equal in regard to treatment, opportunity, and outcomes (Rosenthal & Levy, 2010). Research indicates that individuals with this orientation to diversity are less likely to be persuaded of the need for inclusive practices (Aragón et al., 2017).

The observations of and interviews with Canis team members also reinforced how meritocracy as an engineering cultural value manifested in the team dynamics and reified normative practices focused on technical work as a higher priority over social considerations or endeavors. The Canis team formed and normed quickly with little socialization and engagement beyond a surface-level understanding of each teammate’s potential contribution. Ezekiel, in particular, felt left out of many team activities and frustrated with the lack of deep connections on his team. Our observations of this team did reveal instances of racial microaggressions that ignored Ezekiel’s contributions and separated him from the team. These microaggressions were “subtle, stunning, often automatic, and non-verbal exchanges” (Pierce et al., 1978, p. 66, as cited in McGee, 2016) and are common mechanisms for marginalization in engineering teams (Dickerson et al., 2021). Ultimately this team’s unwillingness to engage in deeper examinations of differences within the

team created less effective storming and norming phases and resulted in exclusionary teaming practices. This finding linking students' depth of engagement in the team formation process with the manifestation of engineering cultural norms echoes and deepens findings from Cross and Paretti (2020), which documented fewer opportunities for friendships and higher instances of conflict due to unmet expectations for African American men on engineering teams.

In contrast, the Apis team began their forming and norming process from the perspective that all teammates came from diverse and varied backgrounds with different skills to offer and to learn from one another. This approach provided opportunities not only for positive interpersonal interactions within the team but also for more positive outcomes from conflicts that arose. Similarly, the Melinae team experience, after re-engaging with the team forming and norming processes precipitated by Thomas's departure, had a deeper socialization process, resulting in more inclusive teaming practices. From these results, we emphasize how deeper engagement within the teaming stages of storming and norming combined with supported learning about difference and inclusion can better support inclusive interactions in teams.

Much of the research on diverse teams in engineering education is quantitative and focuses on how team composition is correlated with outcomes that can be connected to inclusion (like psychological safety, for example; Beigpourian et al., 2019); however, these studies do not provide rich examples of how inclusion within teams is negotiated among team members. Other qualitative studies have most often focused on gender (e.g., Hirshfield & Koretsky, 2018; Tonso, 2006), with one notable study focused on race and ethnicity dynamics within teams (Cross & Paretti, 2020). Our results support findings from these studies on the importance of considering and addressing the impact that cross-gender and cross-race interactions can have on students' feelings of inclusion. It also emphasizes that engagement beyond solely positive interactions within teams to support deeper socialization and engagement with teammates' backgrounds and perspectives can better support inclusive team interactions.

The storming phase and students' engagement with team differences created a strong foundation for successful norming phases. Some teams, like Canis, whether intentionally or not, attempted to shorten the storming phase by ignoring differences or emphasizing the outcomes of teaming rather than the quality of team interactions. As such, the team did not build the necessary trust or skills to effectively discuss team expectations or resolve conflicts.

NEGOTIATION OF CONFLICT IS A KEY COMPONENT FOR INCLUSION

One key finding across our cases was that teams who negotiated intragroup conflict could build trust and clearer communication expectations, leading to more inclusive experiences within the later conflict and performing stages. As described previously, the Apis team had significant conflicts during their storming phase due to differences in approaches to solving problems, lack of clear communication, and fear that a teammate may not accomplish the work at the same standards as oneself. Similarly, the Melinae team engaged in a re-storming process once their teammate, Thomas, left the team. At first, they also attempted to shorten the storming phase and had similar group interactions and norms to the Canis team. However, in the re-storming phase, the team addressed concerns with communication and conflict to create norms that provided more successful and inclusive teaming outcomes.

These storming conflicts are a healthy and common team development process (Jehn & Mannix, 2001). It is important that teams are able to engage productively in the storming phase to provide successful norming experiences. However, the literature in engineering education that focuses on conflict often frames it as a negative aspect of teaming that reduces quality outcomes (Neumeyer & Santos, 2020). We would argue that this framing minimizes the importance of engaging in conflict and can perpetuate the socio-technical divide that often exists in engineering—that is, anything that reduces the quality of technical engineering outcomes, particularly due to interpersonal dynamics, is negative.

Instead, our results underscore how students in engineering teams have interpersonal and instructional opportunity structures for inclusion (Gray et al., 2018), but only if students deeply

engage in the storming and norming processes of team formation. Even with explicit discussions about the importance of diversity and a constant emphasis on the importance of effective teaming within the course context, we found significant variation in students' abilities to engage with particular interpersonal and instructional opportunity structures for inclusion in diverse teams. We provide some implications from this work for particular strategies that instructors can use to better facilitate inclusive team formation and engagement.

Finally, this research provides a novel methodological contribution to the study of inclusion in teams. In this work, we grappled with the complexity of studying DEI within team dynamics. This process involved honoring the individual lived experiences of participants while also working to synthesize the larger team culture, experiences, and dynamics. The use of an IPA annotation framework combined with multi-case study techniques (i.e., individual interviews combined with team observations and artifact collection) provided one way to capture the complex phenomenon. This combination of methodologies and data streams provided a novel way to consider teaming across a semester.

Despite this contribution, we also acknowledge a tension between the various data streams and balancing the perspectives of the individual and team experience. This tension is continuously present in this work, and we struggled to navigate how to represent all the complex parts of our data streams and findings. Our results and discussion highlight the trends that emerged across the teams broadly; this approach to analysis has the potential to mask understanding of individuals' experiences around equity and inclusion during engineering teaming processes. For example, in the Canis team, Ezekiel's experiences with marginalization within his team pointed to the ways group decisions can influence an individual's experiences. In contrast, other students on the team, like Stanley, perceived that the team functioned well and completed quality work on time. Overall, we observed that the team did not engage in inclusive teaming norms that fostered open discussion and did not question the masculine norms in the team. However, we also note that the individual differences present in our findings highlight the challenges of conducting this type of research.

IMPLICATIONS

Our results emphasize that orientations to team development that target recognizing and valuing differences are essential to supporting the creation of inclusive teams in engineering. Multicultural education can provide some guiding implications for engineering educators (Banks, 1997). Multicultural education encompasses a set of philosophical ideologies as well as strategies to incorporate histories, cultures, and contributions of diverse groups in curricula (Hinnant-Crawford, 2016). Research has demonstrated that multicultural education has significant benefits, including supporting perspective-taking (a key outcome in effective teaming and engineering design) and sharpening assessments of discrimination (which is essential for effective team monitoring and correction (Apfelbaum et al., 2012; Todd & Galinsky, 2014). This framing offers implications for how engineering educators can support the storming and norming phases of teaming for inclusion. Here we highlight aspects of multicultural education that are relevant to this study: knowledge construction process, prejudice reduction, and empowering school culture and social structure (Banks, 1993).

KNOWLEDGE CONSTRUCTION PROCESS

Knowledge construction process helps students to understand how knowledge is constructed and how it reflects the experiences, values, and perspectives of its creators. Often in engineering education, diversity in teams is discussed in terms of the "business case" (Ely & Thomas, 2020); that is, more diverse teams produce better engineering outcomes. However, the importance of diversity in engineering work goes beyond the quality it provides for technical engineering solutions. Knowledge construction directly addresses key questions related to social justice and equity concerns in engineering education. As such, it is important for students and educators to understand the history and valuing of certain types of engineering knowledge and relate these

histories to team composition and accepted norms in engineering (Akpanudo et al., 2018; Bejerano & Bartosh, 2015; Carlone & Johnson, 2007; Malone & Barabino, 2009; McGee, 2021). Explicit discussion about the socio-cultural context of engineering can provide starting points to deeply consider how diversity in engineering teams is created. This discussion may be extended into reflective activities within the team about actions they will take to address these considerations in their engineering work together. Attention to these interactions and norms can better support inclusive teaming practices.

PREJUDICE REDUCTION

One of the goals of this work is prejudice reduction or efforts to develop positive attitudes toward different racial, ethnic, and cultural groups. When putting students into diverse teams, there is often an implicit assumption that by learning to do engineering work with others who hold different identities, prejudice reduction naturally will occur (Bauer-Dantoin & Rich, 2005; Beddoes & Panther, 2018). However, particular kinds of processes must happen for those interactions to be beneficial (Johnson & Johnson, 1989; Miller & Brewer, 1986; Paluck & Green, 2009; Pettigrew & Tropp, 2006; Roseth et al., 2008; Wilson, 2011). Regardless of the mechanism, there is a risk in putting students into diverse teams. Without specific instructional opportunity structures to support prejudice reduction, reinforced stereotypes based on prior knowledge can result in microaggressions (Cross & Paretti, 2020; Dickerson et al., 2021). From our results, prejudice reduction occurred when teams engaged in a norming process that explored similarities and differences, built trust, and relied on established relationships when inevitable conflict occurred. When deep socialization did not occur, conflict emphasized differences not previously considered and resulted in exclusive teams. Particularly in introductory courses like those studied here, educators could extend the norming phases of teaming projects to help students consider the ways race, class, and gender influence engineering practice. For example, students could analyze an engineering solution that was not inclusive and ask questions about the implicit assumptions and decision-making process that resulted in the final product. These considerations make explicit who was not engaged or considered in the engineering design process.

EMPOWERING SCHOOL CULTURE AND SOCIAL STRUCTURE

In addition to reframing knowledge construction and reducing prejudice, it is also important to equip students to make reflective decisions and to act for inclusion. Results have shown, including those presented here, that inclusion in the engineering classroom is unlikely to happen on its own (Godwin et al., 2017; Cross & Paretti, 2020; Hirshfield, 2018). As such, educators could shift how students are evaluated in teams to move from the outcomes of teaming to the process of teaming. Asking students what they have learned and value about their teammates can create classroom norms that emphasize the importance of inclusive practices in storming and norming. Students like those in the Canis team may have moved beyond just getting the work done in the most efficient manner to understand one another and learn from one another deeply.

Collectively, the three strategies described above can create teaming environments focused on inclusive and equitable outcomes for all students while reducing the likelihood of putting minoritized students at risk of microaggressions and bias within their teams. This process is neither simple nor prescriptive. Instead, consideration of how team dynamics occur in the engineering classroom while explicitly focusing on integrating multicultural education into the storming and norming teaming processes and creating interpersonal and instruction opportunity structures is essential to more inclusive engineering teams.

LIMITATIONS

We acknowledge several limitations of this study. In this work, we were sensitized to Tuckman and Jensen's formation and development model (1977) along with opportunity structures within the engineering classroom (Gray et al., 2018). These frameworks provided some structure from which to study individual, lived experiences, and collective team dynamics both socially and temporally.

within our chosen cases. However, these frameworks were also limited in their abilities to provide a rich and nuanced examination of the specific actions and engagements within teams and for individuals to support inclusion. The addition of social inclusion to the Tuckman and Jensen (1977) framing provided a useful understanding of the phenomena in this study, but theory for inclusive teams in practice is lacking in the current literature.

Another limitation of this study is the complex nature of the multiple streams of data and the emphasis on the experiences reported in student interviews. Students may have discussed particular aspects of their teaming experience, including a discussion of valuing diversity because they believed that was important to the research team. We did try to mitigate this concern in the way the protocol was constructed, as well as the inclusion of observations of team dynamics to support our findings better, but there may have been some social desirability bias in responses.

CONCLUSION

This cross-case analysis of three first-year engineering teams emphasized how deeply engaging in the process of storming and norming created more social inclusion structures within teams. Our results emphasize that intergroup contact alone is not sufficient for inclusive teaming practices. Instead, careful consideration of how teammates engage with one another and build deeper relationships across racial, ethnic, gender, and ability groups is essential for inclusion. We offer some implications for engineering educators based on the concepts of multicultural education to consider pedagogical practices for more inclusive teams.

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The authors have no competing interests to declare.

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