

# *Student-Faculty Interactions to Promote Equity in Engineering*

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**Abstract**—This full research paper investigates how faculty understanding and preparation to discuss diversity, equity, and inclusion in the classroom affects students' understanding of these topics and abilities to create inclusive teaming cultures. Inclusive teaming is an essential part of engineering education and one of the key ABET student outcomes. However, students are rarely given the skills needed to effectively support truly equitable teaming environments. This ethnographic case study uses data from a single-institution with a core mission of diversity, equity, and inclusion embedded in the vision, mission, practices, and pedagogy. Multiple sources of data were collected including observations, interviews, surveys, and artifacts. This study focuses on the faculty ( $n = 6$ ) and student interviews ( $n = 12$ ) conducted in Spring 2019. Together, these multiple streams of data provide key insights into particular faculty attitudes, philosophies, and practices that support students' development of DEI capacity.

**Keywords**— *First-year engineering, Teamwork, Diversity, Equity, Inclusion, Faculty Perceptions*

## I. INTRODUCTION

Now, more than ever, the need to prepare engineers to work in diverse teams and to create cultures of inclusion is imperative. With the current racial reckoning ongoing in the United States spurred by the Black Lives Matter movement in the wake of the murder of George Floyd, increased attention has been given to ongoing issues of systemic racism. Engineering is not immune from these issues, and has been historically constructed as white and male [1-3]. However, students are not well prepared to understand and implement diversity, equity, and inclusion (DEI) concepts into their engineering practice. Additionally, they do not often receive this kind of instruction as a part of their college

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curriculum, even though the need for such instruction is well researched [4]. Faculty have a significant and unique role not only in helping students learn technical engineering content but also in developing the understanding and capacity to engage in engineering for equity. Faculty shape the institutional norms and changes in faculty have significant impact on institutions and the students who attend them [5]. Several studies of diversity, equity, and inclusion (DEI) education in engineering have focused on how students are motivated to learn about these topics or the impact of particular curriculum or interventions on students' understanding or attitudes [6]. However, fewer studies have focused on how student-faculty interactions set norms for DEI in the classroom and how faculty shape students' understanding and attitudes toward DEI.

Some studies have focused on the impact of personal interaction between students and faculty, and how faculty have the ability to improve the student experience, performance, and belongingness in their undergraduate career [7]. However, there is an opportunity to more deeply explore how instructors set the expectations for and provide opportunities to learn about DEI in their classroom. This study begins to fill this gap by examining faculty conceptualizations of DEI and the influence on what and how they teach within the classroom has on students' understanding and implementation of DEI in their engineering teams.

## II. LITERATURE REVIEW

The importance of the student-faculty interaction on student educational outcomes has documented evidence across higher education. Faculty attitudes and behaviors communicate key messages about the norms and values of engineering. For example, Lundquist, Spalding, and Landrum [8] found that faculty attitudes and behaviors affect retention. A study of student engagement in engineering noted interactions with

faculty as a key factor of student engagement in courses [9]. Briody, Wirtz, and Berger [10] found that many students wanted to be on positive terms with the faculty at their institution. Another study found that faculty behavior was perceived as either “allies” or “adversaries” across various student experiences at both research-intensive and teaching institutions [11]. Together, these studies emphasize that faculty set the tone for what it means to successfully engage in engineering courses.

Faculty also play an important role in how DEI is, or is not, incorporated into the classroom environment. Studies of various student-faculty interactions indicate that there are multiple ways in which DEI is communicated including through syllabi, discussions in class, and behavior that is modeled for students. A study of critical discourse in engineering syllabi indicated that syllabi that engaged inclusive design practices had a significant impact on women’s feelings of belonging in their courses [12]. Another study examined how faculty discuss DEI, particularly gender inequality in STEM. Faculty often used discourse to acknowledge the existence of these issues but did not initiate discussions about taking specific actions to promote equity. The study suggested that institutions should develop faculty that have a more complete understanding of what gender inequity is, and underlying bias they may have, so they can properly promote gender equity in their classrooms [13].

Some work has investigated faculty development on teaching DEI. One study leveraged a professional development model to strengthen faculty cultural understanding and implementation of DEI in classrooms. This study found that the implementation of an inclusive model in the classroom has improved the student’s cultural competence [14]. Another focused on the impact of integrating curriculum activities that focused on the development of engineering identities and built an appreciation of the benefits of DEI. While the activities did not increase students’ engineering identities, they did increase students’ value of diversity in engineering teams. Students cited teamwork as a key factor in learning how to effectively engage DEI concepts in their engineering work [15]. These studies emphasize the role that faculty play in developing students’ abilities to effectively engage DEI concepts in engineering courses.

These prior studies have focused almost exclusively on either student’s perceptions and development or faculty development. Few have examined how faculty attitudes and beliefs affect classroom practices, and in turn, students’ attitudes and beliefs about DEI in engineering. This paper begins to fill this gap by examining both faculty and student experiences of incorporating DEI concepts in an first-year engineering design course with an emphasis on teamwork. All names presented below are pseudonyms.

### III. THEORETICAL FRAMEWORK

Faculty and student interactions are a key aspect in the process of disciplinary socialization. The socialization process describes how students gain the knowledge, skills, and values necessary for entry into a professional career [16]. Faculty shape how students learn about the norms and values of engineering, including how students conceptualize what it means to be an

engineer and how DEI is connected to engineering work or not [17]. Silence about these issues still conveys meaning about what is important or essential in engineering education [18]. As such, understanding the influence of key socializing agents, like faculty, who have experience or knowledge of engineering that shape opinions, skills, knowledge, and expectations on new members, on student attitudes is an area to shape the DEI conceptualizations of students within engineering [19].

### *Socialization in Higher Education*

In this work, we use a framework of socialization to understand how faculty conceptualizations of DEI and practices in the classroom shape students’ perceptions of DEI and its role in engineering work, particularly in their engineering teams. Conrad, Serlin, and Weidman [20] synthesized a multifaceted model of socialization in higher education across several theoretical frameworks including Astin [21-25], Pascarella and Terenzini [26], Tinto [27-28], and Weidman and colleagues [29-30]. This model frames socialization in multiple overlapping spheres including professional communities and personal communities. It also frames the process in an I-E-O (inputs, environment, outputs) of education in the background of prospective students, higher education institutions, and after graduation, novice professional practitioners. Within the environment of higher education, it emphasizes normative processes in both formal and informal settings (i.e., majors, peer groups, and co-curriculum) as well as socialization processes (i.e., interaction, integration, and learning). We focus on the socialization processes in how faculty interact with students; how students feel integrated, which contains both involvement and engagement within a classroom context, and how students learn about DEI concepts as taught by faculty or instructors.

### IV. METHODS

This project focused on identifying how student-faculty interactions set norms for DEI in the classroom and how faculty shape students’ understanding and attitudes toward DEI. An ethnographic case study was conducted in Spring 2019 to understand how faculty conceptualize how DEI is embedded in curricula, how they engage students in conversations and practices within the classroom, and how these pedagogical decisions affect students’ understanding of and attitudes towards DEI in relation to engineering work. The research team collected various kinds of data from a First-Year Engineering (FYE) course class including classroom observations with field notes, pre-and post-term surveys about students’ attitudes, artifacts from courses, images from the classroom and engineering context, and one-on-one interviews with both students (n = 12) and faculty (n = 6). Faculty were asked about how they understand DEI concepts and apply them in their classrooms. Students were asked about their engagement with diversity prior to university, their engagement with their peers, and how the classroom practices set by their faculty instructor may have changed their understanding and attitudes. This study focuses on the interviews collected from the FYE students working in teams and faculty teaching courses to generate insight into how faculty shape student perceptions of diversity, equity, and inclusion and how students enact these behaviors in the classroom. A FYE classroom was selected for data collection because it allows for the observation of the interactions between students from

various engineering disciplines. This is also the first time many students are exposed to peers from different cultures and backgrounds. Therefore, this is a good starting point to observe the impact of faculty teachings of DEI on student development of sensitivity to their diverse peers more clearly.

The data were analyzed by iterative coding systematically searching and arranging the interview transcripts and observation notes of classroom practices that the research team accumulated at the first-year engineering classes at an East Coast university. A constant comparative method was employed to deductively and inductively code for themes that throughout the interviews. Deductive codes came from previously developed codes based on themes identified from a similar study at a large Midwestern university [cite redacted], and were applied when analyzing this data. Inductive coding followed a two-step process which included descriptive coding and linguistic coding. Descriptive coding focused on the content of student and faculty descriptions, which generated an inventory of various themes occurring throughout the interviews. Linguistic coding consisted of analysis of the patterns in language, the student's words/phrases when responding to questions, and when they choose to use specific phrases. The second cycle of the coding process consisted of pattern coding where the larger themes that emerge across both the descriptive and linguistic codes were identified. [32].

The positionality of the research team in conducting this work is an important part of the reflexivity and quality considerations within this study [33-34]. The data for this study were collected by the second, third, and fourth authors. The data were analyzed by the first author in collaboration with the second author. The team identifies as one Asian-Indian woman, one white woman, one Black-Latina, one Latino, and three white men. Throughout this study, the team has regularly engaged in discussion of how these identities impact multi-layered experiences of power and oppression as well as how these positions influence this work on understanding diversity, equity, and inclusion in engineering teams. The process of synthesizing research findings is collective and by consensus to account for the multiple experiences and perspectives of the research team and the nature of the data.

## V. RESULTS

This paper reports the impact of various faculty teachings of DEI on students' value of diversity and willingness to engage in inclusive practices while in engineering teams. We found three key themes across the faculty and student interviews: 1) Making DEI a regular and common discussion in the classroom positively shaped students' attitudes and actions; 2) Often students had not considered DEI concepts outside of their own experience. Faculty providing specific strategies for inclusive teaming was necessary to support students' learning and successful engagement in their teams; and 3) Faculty often expressed a lack of preparation to engage DEI in their teaching, which corresponded to the depth of their engagement in these DEI discussions in their courses. Due to limited space, we present data from two faculty interviews and discussions from students enrolled in their classes to illustrate these themes.

### A. DEI as a Regular and Common Discussion

The common curriculum in the first-year engineering design course included an explicit discussion of DEI in the first week of classes, particularly in relation to engineering teamwork. Each faculty member engaged in this discussion. However, some faculty more regularly referred to this discussion or brought up conversations about DEI throughout the course, while others relied on "covering" this topic early on in the course. Everyday conversations about DEI within the classroom had dramatic impacts on how students not only understood core concepts but also how they approached valuing diversity and working within engineering teams. Women, in particular, discussed how open conversation about DEI made them feel empowered or supported in engineering. For example, Katie shared:

[Dr. Kennedy's] not ... doesn't act like it's not there. I've noticed he doesn't put a girl in a group by herself. There's always another girl, at least another one. He's very upfront like, "Hey." When we were talking about roles like don't make the girl the secretary. It happens a lot. They did the study, and he'll go into it and he'll explain why. If there's a sense of it could be like that he'll go into it and he'll be like, "Hey, guys if you see this don't let it happen. Say something. Do something." I think that's very helpful because instead of ignoring it and pretending like it's not there you're addressing it and you're fixing it."

Katie went on to describe how the regular discussion of DEI shaped her understanding and interactions in her team:

It was kinda telling us the importance of diversity on engineering teams and how someone coming from a different background has a different perspective on what you guys are doing than you do. Everyone has a different ... having a group of people with the same idea and the same thoughts all the time can be harmful to a group of people that is not in that inner circle of how they think, what they do and how their life was.

Throughout the study we observed a week of classes and found that Dr. Kennedy regularly discussed DEI as a part of his teaching. He described his approach to teaching DEI as,

It's easier to talk directly about, the team has to work regardless of differences on it, and Industry has people that are different...What's going to happen is they're going to take things over. They're going to act in ways that don't respect their team members implicitly. So a lot of the work that can be done and needs to be done is to break the implicit habits and to get them in a mode where they're more used to just treating and working people that aren't like them, like people.

In contrast, we asked another professor, Dr. Conlan, about how DEI was incorporated into his classes, he responded,

That's an interesting question because that's never been an issue for me. I've never thought about that [DEI]. I've always been in a pretty heterogenous kind of environment where there's been lots of different folks,

different backgrounds, different capabilities, different ethnicities, different genders, it just was not an issue. I've never explicitly thought about that.

When asked about any specific things he taught about DEI in his classes, he said, "Not specifically, but it is implicit in the ethics portion, which is the first three weeks of class."

Dr. Conlan's students described their engagement with DEI in very different ways than the students in Dr. Kennedy's classroom. John said,

I honestly, when I hear diversity, don't get offended or anything, I just think of Black people and white people if they can mesh together. I don't hate anybody, I accept everyone for what they are. I'm not going to be like "Oh yeah, I'm not really worried about it". If I see like- I'm not trying to be racist or anything, but if I see, you know a white guy or a black guy in an alley way, I'm gonna feel kind of scared even though I'm 6'7", I'm still going to feel kinda scared, like what they have a gun why are they in an alleyway, who do they have their hood up, no matter what color you are.

Johns' beliefs reveal a highly racialized conception of Black men that he justified as his personal safety rather than acknowledging these attitudes as rooted in white supremacy and racism. John embodies a typical aversion to being labeled as racist while upholding racist ideals [35]. John never critically examined his conceptualizations of DEI or the connection between these attitudes and his engineering work.

### *B. Specific Strategies for Inclusion*

Many students had not deeply considered DEI before attending university. For example, West said, "I don't think I've ever thought about it [diversity] as personally as I do here because there's a big focus on that. So, it became more important as a result." John's experience was reflected in many student interviews. Students who were in classrooms that incorporated DEI regularly into conversations also felt that they had learned specific strategies to be inclusive. West went on to say,

I feel like some members are a little more sensitive to it [criticism] than others. But generally we're all able to keep it real with each other and explain what's up, how we feel? [Dr. Kennedy] gave us a specific outline for ... Okay, that was more for when fighting. But basically we all have sort of reached the point where we can clearly explain and calmly explain without, like, sparking anger what exactly our thought process is, and I'd say the vast majority of the time people are understanding and willing to either explain their side a little more in depth or listen to what you said and go with that. We're all supportive of each other and that's like the most important thing.

Many students in Dr. Kennedy's classes described roles, actions, and practices that they found useful in intentionally creating inclusive teaming environments.

### *C. Faculty Preparation to Teach DEI*

In interviews, faculty discussed various depths of reflection on their own experiences, considerations of power and privilege,

and their role within the engineering classroom in creating inclusive environments. For example, Dr. Kennedy shared,

There's affordances of my male privilege that are effective in forwarding my career, my power, prestige, and influence inside the program and inside the university. I think I can say things and do things that are harder for other people to say and be able to, even inside engineering. I feel like in our meetings it's still easier for me to talk.

When Dr. Conlan was asked about how he incorporated DEI in his teaching, he responded, "I'm hoping that is a reasonable way to include diversity, I hadn't thought about it explicitly, though. That's a challenging one, I'll have to think more about that." He went on to describe an example of how he was still learning,

I did not realize that women faculty have different challenges from male faculty, particularly in being accepted for their basis of authority. One of, probably the second faculty meeting, I was shut down very quickly when one person was sharing that they were having trouble admitting a vulnerability because they were already fighting the fact that they were from a particular background and gender, but I didn't recognize that. For me, if you make a mistake, you just admit it and say, "I made a mistake, here." I started to say that and I got shut down very quickly by the other male faculty member [Dr. Kennedy] because, he made it very clear, I was old, white male and we have a different social standing in society than women. And I was like, "I didn't know that" and I hadn't recognized it so I'm learning.

Dr. Kennedy and Dr. Conlan had very different definitions of DEI and had engaged in more or less reflection about their positionality within society of white and male engineers. Dr. Kennedy described confidence in his ability to teach DEI, while Dr. Conlan indicated less consideration and more discomfort with the topic. Both indicated an orientation to continuing to learn in their practice.

## **VI. DISCUSSION**

The findings from this study have implications for how DEI is taught in engineering courses, particularly within teaming environments. Frequent and normative discussion of DEI as related to engineering work created environments in which students discussed DEI as an integral and important part of their teamwork. This socialization process created these cultural norms that valued DEI and provided way to bridge the social and technical divide often present in engineering environments [36]. This effort also begins to dismantle the masculine and white norms of engineering [37-39]. Our work describes the positive impact of providing these discussions for students' development and engagement with DEI. Additionally, faculty should not only engage in discussions of DEI conceptually but also provide specific strategies for students learning to create inclusive environments in their classrooms. Faculty who provided these explicit discussions of the learning process and how DEI could be practically addressed in students' teamwork, had students who were more deeply engaged in thinking about DEI in their work and considered DEI an important part of their

engineering course. In contrast, faculty who did not engage in regular discussions or provide practical strategies had students who supported exclusionary and harmful attitudes. Our work adds to the body of literature on teaching DEI in engineering by understanding how faculty perceptions of DEI, personal reflection and growth, and conversations in classes shape students' understanding of these topics and their importance in engineering work.

Results indicated that students will not learn skills for creating equitable and inclusive environments passively. Rather, DEI must be an explicit part of the curriculum that is regularly revisited in discussions and key learning outcomes in order for DEI to be considered a valuable engineering skill. Previous studies in engineering indicate that while students become more aware of DEI in a first-semester, first-year engineering course with explicit instruction, they are less willing to act to foster DEI [40]. The results of this study show that by moving to continual integration of DEI in our instruction, we may be able to get students to act within their engineering teams to foster DEI.

However, for these discussions to be a regular part of teaching, faculty need to reflect on their position within engineering, their classroom, and institution and society more broadly and how that position influences what and how they teach. Through these reflections faculty must also focus on learning to become anti-racist, anti-sexist, and how to implement inclusive pedagogies effectively [41-43]. This development does not need to happen all at once, and should happen within a larger community of supportive colleagues and administrators; however, it does need to be a priority to have transformational change. Our work continues to emphasize the importance that DEI is not an add on or separate component of engineering teamwork. Instead, it must be intentionally incorporated by faculty who understand their role in shaping DEI in their classrooms and in peer-to-peer interactions within teams through the process of socialization. The classroom is a space in which the norms and values are an agreement among members about behavioral expectations and interpersonal interactions. Both what is said and unsaid communicates if and how DEI is related to engineering work. Instructors can shape norms that support academic success, belonging, and the formation teams with inclusive behaviors through how they approach DEI conversations [44].

## VII. CONCLUSION

We found that the everyday conversations about DEI within the classroom as a part of engineering socialization had dramatic impacts on how students not only understood core concepts but also how they approached valuing diversity and working within engineering teams. Engagement with DEI concepts and working within diverse teams supported students' awareness of and engagement with DEI in engineering. However, some faculty did not feel well prepared to engage in conversations about DEI within the classroom. They often chose to focus on engineering content and did not openly discuss DEI. Students in these classrooms indicated they had more negative teaming experiences and did not show the same gains in understanding and willingness to engage with DEI concepts in engineering practices.

It is clear from this work that faculty play a significant role in the education and development of engineering students. Our research points to particular impacts of how faculty preparation and teaching practices shape classroom norms. This work provides a larger insight into the various components of an engineering ecosystem to support student development of DEI capacities.

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