Title: Linking Engineering Students' Professional Identity Development to Diversity and Working Inclusively in Technical Courses

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Title

Linking Engineering Students' Professional Identity Development to Diversity, and Working Inclusively into Technical Courses

Abstract

Despite growing efforts, diversity, equity, and inclusion initiatives have yet to address long-standing engineering participation disparities. Often, diversity and inclusion issues, along with other societal challenges, are perceived as unrelated to engineering. Conversely, engineering as currently practiced and taught is embedded in dominant culture norms that are frequently invisible to majority students and faculty. One strategy to shift this erroneous "neutral" perspective is to integrate diversity and inclusion into engineering curricula. Using inclusive professional identities as a theoretical lens, we developed an activity that incorporates diversity and inclusion into the technical content of Engineering Mechanics: Statics. Using thematic analysis, we found that students' responses to prompts about the student's own identity, engineering as a profession, and the student's perceived learning revealed two primary themes: teamwork and engineering/ math-related skills/ experiences. While diversity and inclusion were included in responses, students did not connect diversity and inclusion to engineering as a profession. Therefore, students may need more support to make this connection. While singular activities cannot explicitly overcome racism, sexism, or other deeply entrenched biases in our society, the activity type we describe may help students develop a more holistic perspective of engineering and understand the importance of addressing biases in their future engineering careers.

Keywords:

Diversity, equity, civil engineering education, thematic analysis, inclusive professional identities

Introduction

Engineering education and professional practice continue to lack diversity in the United States even though calls to diversify the profession are long-standing. The founding of the professional societies, such as the Women's Engineering Society in 1919, the Society of Women Engineers (SWE) in 1950, the Society of Hispanic Professional Engineers (SHPE) in 1974, and the National Society of Black Engineers (NSBE) in 1975, demonstrate efforts to diversify engineering (National Society of Black Engineers 2016; Society of Hispanic Professional Engineers 2020; Society of Women Engineers 2020; Women's Engineering Society 2019). Moreover, the U.S. Congress passed the Equal Opportunities in Science and Engineering Act of 1980, establishing the Committee on Equal Opportunities in Science and Engineering to advise the National Science Foundation to broaden participation in the STEM workforce (Committee on Equal Opportunities in Science and Engineering 2004). Thus, increasing representation has been a routine part of the conversation about the desired future of engineering for the past 40 years, joined more recently by concern about the lack of inclusion in professional and educational settings. In discussing this lack of diversity and inclusion, we either use the term marginalized identity as a general term to refer collectively to identities that are frequently excluded in some way, or, we use the specific identity terms used in the papers we cite.

The National Science Foundation has made a significant investment in STEM and engineering-specific outreach, scholarships, mentoring programs, summer bridge activities, and various co-curricular activities offering targeted support to students with marginalized identities (Committee on Equal Opportunities in Science and Engineering 2015). Yet, despite these efforts, the lack of diversity and inclusion in engineering persists. In over twenty years of concerted effort to broaden participation in engineering, the percentage of bachelor's degrees in engineering earned by women has increased from 18.4% in 1997 to 20.9% in 2019, and engineering bachelor's degrees for Blacks and African Americans declined from 4.93% to 3.86% (National Science Foundation 2019).

In the same period, engineering bachelor's degrees for Hispanics increased from 6.6 to 10.4 % (National Science Foundation 2019). While these numbers give us some perspective about who is earning degrees, tracking percentages of engineering bachelor's degrees alone can be misleading. For example, women have been earning more bachelor's degrees overall than men since the 1980s, meaning the number of engineering degrees earned by women as a proportion of the total degrees earned by women has shown little gain or actually declined (Su 2010). Further, the low engineering degree attainment by Black, Hispanic, and Native American students can be explained largely by lower participation in higher education overall (Su 2010). In fact, by considering the number of engineering degrees earned per 100 bachelor's degrees, it becomes apparent that in 2005 Black, Hispanic, and Native American women were earning a higher share of their degrees in engineering than white women; that Hispanic men were earning engineering degrees at a slightly higher rate than white men; and that degree gaps between white and Black and Native American men were much smaller (Su 2010). However, these gaps due to lower participation in higher education overall do not mean a lack of problems in engineering, but rather point to broad-scale systemic problems that include engineering programs. In discussions of representation and degree attainment, Asian students are often left out because they are over represented in engineering relative to their share of the U.S. population, however Asian students are still likely to encounter classroom settings with few other Asian students and can still be subject to discrimination.

Although the details of diversity and representation are complex, the fact remains that engineering lacks diversity and students from marginalized identities are more likely to feel isolated, and their experience in engineering degree programs will be different from those with dominant identities (continuing generation cisgender heterosexual white men). Notably, these data are limited to commonly tracked identities. For example, there is no widespread data about queer people in engineering (those who do not identify as both cisgender and heterosexual), but queer students in engineering programs are proportionally more underrepresented than women (Casper et al. 2020) and face both exclusion and discrimination (Cech and Rothwell 2018; Cech and Waidzunas 2011).

Beyond the lack of engineering participation, people with marginalized identities are often excluded or tokenized in workplace cultures. For example, the Pew Research Center found that 50% of women in STEM fields reported experiencing gender-based discrimination at work, compared to 19% of men. In STEM workplaces with a majority of men, 78% of women reported experiencing gender inequities (2018). The same survey found that 62% of Blacks, 44% of Asians, and 42% of Hispanics in STEM positions reported experiencing racial/ethnic discrimination at work compared to 13% of whites. And only 37% of Blacks believed that Blacks are usually treated fairly in opportunities for advancement and promotion (Pew Research Center 2018). Engineering faculty and professionals with queer identities face unwelcoming climates where they are marginalized and harassed, their ideas are discredited, and they are excluded from vital professional networks and resources (Bilimoria and Stewart 2009; Cech 2015; Cech and Pham 2017).

Working towards equity is critical in its own right to address systemic injustices and systems of oppression. The increasingly common discussions around diversity within higher education will not make real change without addressing inequities built into our current education systems. These changes rarely happen without interest convergence – when the interests of a dominant population benefit from creating change that moves towards diversity and inclusion (Garces, Ishimaru, and Takahashi 2017; Bell 1980). While it is vital to focus on equity as a social justice issue, the enhanced returns that inclusive cultures can bring can also help drive much-needed change through interest convergence. For example, Hong and Page (2004) showed that for complex problems, a team of cognitively diverse problem solvers, each bringing different problem-solving approaches, outperforms a team of the “best” individual problem solvers, as the latter are likely to approach problems similarly. Similarly, Hunt et al. (2015) found that ”companies in the top quartile of racial/ethnic diversity were 35 percent more likely to have financial returns above their national industry median” (p. 1).

The lack of diversity in engineering is commonly addressed through a deficit perspective, which assumes (explicitly or implicitly) that those with marginalized identities lack the skills, abilities, and background to be as successful as their peers (Gill et al. 2008; Smit 2012). In other words, deficit perspectives assign the problems caused by systemic discrimination to an individual rather than addressing the large-scale systemic issues. Additionally, those with marginalized identities who internalize deficit perspectives may believe and propagate these perspectives, enforcing an unsupportive culture (Gill et al. 2008).

Using a deficit perspective as a lens for educational reform is erroneous and harmful because it assumes that marginalized students are somehow less than. It also fails to address systemic barriers that propagate inequities (Estrada et al. 2016). For example, due to historical and current practices that explicitly privilege white homeownership, such as redlining and sub-prime mortgage lending, Black, Indigenous, and People of Color (BIPOC) disproportionally live in lower-income neighborhoods (Hernandez 2014). Lower-, middle-, and upper-income students have similar academic aptitudes, but when property taxes fund schools, schools in lower-income neighborhoods receive fewer resources, often under preparing students (Cullinane and Leewater 2009; Estrada et al. 2016). Providing specific paths for students to gain needed math skills should be paired with programs that allow low-income students to leverage their strengths and engineering skills (Estrada et al. 2016).

Society benefits from greater diversity in the engineering profession, particularly when that diversity is paired with engineers trained to work in inclusive ways, allowing the benefits of diversity to be realized. Issues of diversity, inclusion, and other societal-related challenges, are often seen as external and unrelated to engineering (Cech and Sherick 2015). The view that engineering is a purely technical field that can be isolated from the society in which engineers live and work is termed de-politicization by Cech (2015). On the contrary, engineering is embedded in dominant culture norms frequently invisible to those with culturally dominant identities (Cech and Sherick 2015). Efforts to recruit more diverse students and address issues in engineering pathways have made some gains, but not enough (National Science Foundation 2019).

Further, addressing diversity from only a quantitative perspective, without also addressing the culture of workplaces or educational settings, is problematic; focusing solely on diversity without also addressing equity and inclusion fails to address why there is a lack of diversity in the first place. Therefore, rethinking how we approach the issues of diversity and inclusion in engineering is of great importance. We argue that instead of using a deficit perspective, we need to focus on changing the climate and culture of engineering classrooms and the profession (Estrada et al. 2016; Cech and Sherick 2015). One strategy to help remove or reduce the depoliticized engineering perspective is to integrate diversity, inclusion, and other societal related issues into engineering curricula (Cech and Sherick 2015; Hartman et al. 2019; LaFave, Kang, and Kaiser 2015). Course activities that directly connect diversity and inclusion to engineering practices demonstrate the relevance and value of larger social and cultural components (Cech and Sherick 2015; Hartman et al. 2019; LaFave, Kang, and Kaiser 2015).

This paper describes a new curricular activity intended to integrate diversity and inclusion into the technical content of Engineering Mechanics: Statics, a commonly taught technical engineering course; and an analysis of student responses to the activity. The intervention effort in the Statics course is part of a larger project to cultivate inclusive professional identities through curricular change, which includes interleaving diversity and inclusion-related activities throughout both an individual course and the engineering curriculum as a whole. Key goals of the activity were to help students a) identify a breadth of their personal characteristics that allow them to contribute uniquely to engineering teamwork and problem solving, b) value diversity as necessary in the engineering problem solving process, and c) apply team problem solving to a realistic engineering situation. It is important to note that the framework and diversity and inclusion aspects of the activity are general and can be readily adapted to almost any course. As such, our additional goals were to create an activity that: a) instructors felt comfortable and confident implementing (minimizing the discomfort of discussing social issues in the classroom), and b) provides an introduction to diversity and inclusion, which students would build upon in future activities. Because activities related to social issues can have a backfire effect if they threaten students' worldviews (Darner 2019), as described by Rottman and Reeve (2020) in a gender intervention for engineering students, we wanted to provide students with a diversity and inclusion activity that minimized the likelihood of backfiring. While we do not expect this one activity to create large-scale long-standing change on its own, it is a stepping-stone as part of our larger-scale curricular change (Atadero et al. 2018). In the background section, we describe the overall project, its theoretical basis, and our definition of inclusive professional identities. We then describe the intervention, along with data collection and analysis procedures. As related to their own identities and their conception of the engineering profession, student responses to the activity are presented. Finally, we offer a discussion of the implications of this work and areas for further investigation.

Background

Inclusive Professional Identities

Undergraduate engineering degrees are professional degrees, in the sense that students who complete a bachelor's degree in Engineering can be hired directly into engineering practice. Students will still need to learn specific skills and knowledge sets in the field they choose, and many may pursue graduate-level coursework at some point. The recognition that most students who earn an engineering degree are planning to become practicing engineers has increased emphasis on professional skill development in engineering degree programs. This emphasis includes student learning outcomes from ABET, the accreditation body for engineering programs in the U.S. Furthermore, researchers in the field of engineering education have sought to understand how students “become” engineers through NSF programs such as the Professional Formation of Engineers program. One area of interest has been in engineering identity as a professional identity and how students form an engineering identity.

The current study is an activity under the Partnership for Equity (P4E) collaborative research grant funded by the National Science Foundation. The P4E project seeks to promote greater equity in engineering degree programs and, ultimately, the engineering profession by engaging *all* students in lessons about diversity, equity, and inclusion within an engineering context. The P4E project is rooted in the theory of “inclusive professional identities,” which draws from professional identity development theory and social justice perspectives on diversity, equity, and inclusion (Atadero et al. 2018). Identity itself is a narrative construction that changes over time; it is developed through each individual's inner narrative (Eliot and Turns 2011). Professional identity development is the process that individuals go through as they identify more with a given profession’s duties, responsibilities, and knowledge, and is not necessarily an intentionally facilitated process (Eliot and Turns 2011, 631). The process of professional identity formation is influenced by internal factors, such as deepening one’s understanding of professional practices, and external factors, such as interacting with peers, faculty, and professionals (Eliot and Turns 2011).

Professional identity development depends on an individual’s understanding of the profession (Trede, Macklin, and Bridges 2012). Depending on student’s prior influences, their knowledge of the engineering profession might be incomplete or flawed, but in either case, it will be further shaped by their undergraduate curriculum (Eliot and Turns 2011). Diversity, inclusion, and equity are deeply relevant to the work of engineers. Still, the messages students receive about engineering before they start college and in their undergraduate degree programs can ignore or obscure the connections between diversity, equity and inclusion and engineering practice (Cech and Sherick 2015; Eliot and Turns 2011). The P4E project seeks to offer students a deeper understanding of the engineering profession. As they are forming their own professional identities, diversity, equity, and inclusion are contributing components (Atadero et al. 2018).

While the activity described in this paper focuses on diversity and inclusion, the ultimate goal of the P4E project is to cultivate inclusive professional identities, which require individuals to integrate diversity, equity, and inclusion components into their professional identities in all engineering students. We identify five key characteristics of an engineer with an inclusive professional identity: competence in applying disciplinary knowledge, skills, and abilities; appreciation of how diversity strengthens a discipline; ability to act in inclusive ways and create inclusive environments; consideration of an endeavors impact on diverse populations; and appreciate the need to participate in life-long learning practices related to engineering diversity, inclusion, and equity.

For students to enact the characteristics we identify above as part of diverse professional identities, they must first value diversity in themselves and others. This valuation requires the perception of diversity as a broad, multidimensional concept that includes gender, race, sexual orientation, age, geography, language, socioeconomic status, first-generation status, cognitive diversity, and numerous other components (Atadero et al. 2018; Gutierrez, Paguyo, and Mendoza 2012; Page 2007). As such, students must include both visible and invisible diversity in their conception. This broad definition of diversity is essential, in that diversity initiatives that focus on race and gender while excluding other dimensions of diversity are likely to fail (Rasmussen 2007). Inclusive professional identities are rooted explicitly in equity perspectives rather than deficit-oriented views. As discussed above, students with marginalized identities are often seen as deficient (Sólorzano, Villalpando, and Oseguera 2005); in contrast, perspectives rooted in equity see the knowledge and expertise that all students have (Estrada et al. 2016; Smit 2012). An additional goal of this integration of diversity and inclusion into their professional identities is to help broaden perceptions of who can be or is an engineer (Atadero et al. 2018).

Incorporating Diversity, Equity, and Inclusion into Engineering Courses

To cultivate inclusive professional identities in all students, P4E works to integrate diversity, equity, and inclusion (DEI) content into classes so this content is not considered separate from engineering. In this way, the instructors can intentionally facilitate the integration of inclusivity into students' professional identities (Atadero et al. 2018). While there is growing interest in integrating DEI curricula into engineering courses, (Hartman et al. 2019; LaFave, Kang, and Kaiser 2015; Atadero et al. 2018; Koretsky et al. 2018), students are still often expected to receive this content as part of their all-university core requirements; even in a university with an explicit university-level committement to diversity, instructors did not necessarily think teaching about DEI was their responsibility, particularly in STEM courses (Gordon et al. 2019). In general, even if instructors think it is their responsibility to discuss diversity-related content, university faculty feel that they need more training to address diversity-issues in the classroom (Park and Denson 2009; Gordon et al. 2021; 2019). We argue that engineering students need to encounter content that addresses diversity and inclusion within their engineering courses to recognize the relevance of diversity and inclusion to engineering practice (Atadero et al. 2018; Cech and Sherick 2015; Ihsen and Gebauer 2009). However, as demonstrated by recent DEI-related papers presented at the ASEE conference, including the past papers nominated for the best DEI paper award, DEI research in engineering education is still heavily focused on extra- or co-curricular activities and papers related to integrating DEI into engineering courses is still rare (American Society of Engineering Education 2019). Critiques of a depoliticized, technical-focused engineering education call for integrating diversity, inclusion, and equity in engineering coursework, as a vital component to re-politicizing engineering education. Some institutions have taken steps towards this integration (Cech and Sherick 2015; 2015; Koretsky et al. 2018; Ihsen and Gebauer 2009; Leicht-Scholten, Weheliye, and Wolffram 2009; Peixoto et al. 2018). When LaFave et al. (2015) integrated cultural competency work into a senior-level structural engineering course, they noted increases in student competency. Additionally, intercultural competency better predicted a group's performance on the highly-technical final project than the group members' mid-term grades.

Infusing diversity and inclusion in current engineering curricula are challenging for various reasons, including the barriers created by typical instructional strategies and departmental culture (Ihsen and Gebauer 2009). Common engineering instructional strategies often include traditional approaches to education, focusing on developing specific learning tools rather than holistic or integrative solutions (Freire 2000; Hernández-de-Menéndez et al. 2019; Ochoa and Pineda 2008; Riley 2003). This approach to knowledge may not be explicitly stated, but rather may serve as a cultural assumption that makes it possible to discount or ignore more personal or immediate knowledge, such as knowledge about identity or interpersonal interactions (Lemke 2001). Additionally, even when instructors value diversity content and believe it would lead to better instruction, they are unlikely to integrate it into their courses unless their department has a culture that supports diversity-oriented content (Mayhew and Grunwald 2006; Park and Denson 2009). Therefore, merely making a diversity-oriented curriculum available is not enough to create systemic change; engineering colleges and departments need to create a culture that explicitly and implicitly values this content as well (Mayhew and Grunwald 2006).

There is a clear need to change the curriculum of engineering programs to address the persistent challenges of representation and culture in the profession and to prepare students most effectively for professional practice. While engineering faculty may support initiatives to incorporate diversity and inclusion content into engineering, barriers regarding past practices and faculty inexperience/uncertainty remain (Mayhew and Grunwald 2006). Due to this lack of best practices and the challenges of bringing social topics into courses that are often focused on numeric right answers, the results of prior work to integrate diversity and inclusion topics into engineering and related STEM curricula have been mixed (Atadero et al. 2018; Bartilla and Köppe 2015; Godwin, Kirn, and Rohde, n.d.; Rottmann and Reeve 2020). It is particularly important to create activities that do not trigger a backfire effect (Darner 2019). In this paper, we argue that making diversity and inclusion content relevant to technical content can be an important means of making diversity and inclusion content feasible for engineering instructors and palatable to engineering students, and provide a starting place to help students initially understand existing problems, a key step in helping students to value diversity and inclusion (Atadero et al. 2018; Bartilla and Köppe 2015; Chi and Roscoe 2002; Hartman et al. 2019; LaFave, Kang, and Kaiser 2015).

Objectives of this Study

Through this lens of inclusive professional identities, we use a newly developed course activity integrating diversity-oriented content into a technical course to explore characteristics of a) students' own identities that they described as relevant to engineering and group work, b) students' perceptions of engineering as a profession, and c) what students identified as learning from the two-part intervention focused on diversity and teamwork in engineering. We were specifically interested in how students wrote about what they learned. Even though this may not accurately represent their actual learning gains, it provides insight into the aspects students valued in the learning process or those aspects that students thought we wanted them to value. In all three of these areas, we focused on exploring if students focused on technical engineering components (e.g., math, equations, computer skills) or, more broadly, included professional skills and other aptitudes (e.g., teamwork, hobbies, academic interests in other realms). Additionally, we evaluated how students integrated the diversity-oriented messages in our intervention into their responses. To explore these objectives, we asked:

1. **Personal Identity:** what types of characteristics do students write about as salient to engineering? Do they include a broad range of components, including diversity-related topics?
2. **Engineering as a profession:** do students include diversity and teamwork as components of the profession? Do they write about erroneous stereotypical characteristics (e.g., engineers work alone)?

3. **Student-reported learning:** What activity components and learning outcomes do students focus on when reporting about their learning? Are these primarily technically focused, or do they cover broader topics that include non-technical content?

Methods

This study was performed by two engineering faculty, one STEM education faculty, and one STEM education research scientist. The course instructor, one of the engineering faculty, was the only author not involved in data analysis to avoid a conflict of interest. The other engineering faculty author, who was the inter-rater coder, helped in the classroom on group work days to answer questions, and therefore brought both content and contextual knowledge of the activity to the coding process.

Course Context and Participants

The course activity was taught in two sections of Engineering Mechanics: Statics (hereafter Statics) in the fall 2018 semester at a large R1 university in the Western United States. Both sections were taught by an instructor who teaches Statics and Dynamics full time and had taught Statics to over 1700 students over the previous six years. The total enrollment for the semester was 231 students across two sections. During the intervention activity, all students were invited to participate in the study, and 162 (70%) students consented to have their responses analyzed (IRB #102-15H). All data, including demographic data, are presented only from the consenting students. While we do not have access to the specific demographic information for non-consenting students, the demographics of those who consented are generally representative of the class enrollment as a whole, and are similar to the institutionally published data for the College of Engineering (72% white, 11% Hispanic, 4% multiracial, 1% Black, 7% international; 25% women). The course is a required course for students majoring in mechanical (29% of students), civil (33%), biomedical (20%), and environmental engineering (6%). The course also included students from engineering science (4%) and other departments (3%). Students typically take the course during their second year, with 40%

qualifying as sophomores, 44% as juniors, 8% as seniors, 0.6% as second bachelor's, and 0.6% as a master's student. Based on institutional demographic information for race and ethnicity, which is limited by the categories the institution uses for data collection and how students choose to identify themselves to the university, the students were 74% white, 10% Hispanic/Latino/a, 6% multiracial, 2% International, 1% Black, and 3% of students selected "other." Gender is similarly limited in this study, as even though gender is not binary, the institution collects data as such. Twenty-six percent of students were women, and 70% were men. The institutional data also indicated that 13% of students were first-generation college students. We lacked departmental, class standing, and demographic information for six students, or 4% of those who consented to participate. Students taking Statics in this semester who completed first-year courses at the institution may have encountered diversity and inclusion or teamwork content in their first-year engineering course. This institution has department-specific first-year courses. Civil and Environmental Engineering has had more consistency in their first-year instructors, offers the course only in the fall semester, and has participated in the P4E project since 2015, meaning most civil and environmental students have participated in prior activities. Mechanical Engineering has had more change in their first-year courses and course instructors and offers the course in both the spring and fall, so we are less certain how much exposure mechanical and biomedical engineering majors would have had before taking Statics.

The Activity

The intervention activity had three parts: 1) an online pre-class activity, 2) an in-class team problem to solve, and 3) an online post-activity reflection. We piloted the activity in spring 2018 before the fall 2018 iteration presented in this paper (Hedayati Mehdiabadi et al. 2019). We conducted the pre-class activity and post-activity reflection using the Canvas course management system. Teams started the in-class problem during class time, but most needed some additional time outside of class to complete their calculations.

For the online pre-class activity, students were assigned to watch and reflect on a short video about the role of diversity (particularly diversity of thought) in the knowledge-based economy and its impact on team problem solving (Page 2016). After watching the video, students were asked to respond to a set of four reflection questions. Two questions asked students to reflect on their skills, abilities, and components of their identities and how they might be unique from their peers in their problem solving process. Two questions asked about teams' characteristics and problem-solving environments to facilitate quality solutions (Appendix A). Students' responses to these prompts ranged in length from one to several sentences. As this activity graded for completion and was conducted similarly to all other course activities, we did not see any indication of students providing poor-quality responses instead of fully responding to the prompts.

Teams started the in-class problem during a single 50-minute class session. The cooperative learning technique used is commonly known as a jigsaw activity. Jigsaw activities are a three-step process: 1) students in a home group are assigned a problem to work on, 2) when the groups start needing help, home groups split to send members to class-wide expert training groups, and 3) the experts reconvene in their home groups to share their new knowledge. In our activity, home groups had four students; in Section 1, students were semi-randomly assigned to home groups, which were adjusted to include two or more women. In Section 2, students self-selected their home groups. The assigned problem was designed as a "stretch" problem (containing content they had not yet learned), which expanded their knowledge about shear and moment diagrams to the design of a crane-rail for a moving crane (Figure 1). Students had the technical knowledge needed to solve the first portion of the problem, but the design context in the latter portion came from a structural engineering course, which is taken about one year after Statics. After breaking into home groups, students were shown a small Lego model of the crane frame. Each home group was given about ten minutes to get started on the problem and ask questions. During this time, two instructors circulated to answer questions. Next, home groups split to send each member to one of four expert training groups in each corner of the room. Each expert training group had a unique hint meant to simulate different perspectives on problem solving. For example, one hint asked students to consider the effect of the moving crane load on the maximum shear and moment experienced by the crane rail. Another hint gave students design tables from the AISC Manual of Steel Construction and guidance to help them pick an appropriate shape. Each expert training group discussed their hint with fellow experts from other home groups and an instructor or learning assistant before rejoining their teams with new knowledge about how to solve the problem. Teams then had the rest of the class period to work in their home group, and the instructors continued to circulate answering questions during that time. Students then completed the crane rail design problem to submit as a homework problem.

For the online post-activity reflection, students answered reflection questions about what they learned while working on the activity, including what they learned about working in teams and about engineers' roles and responsibilities (Appendix B).

Data analysis

After students had completed the activity, consenting students' responses were organized by question and anonymized before analysis. While answers to all questions were analyzed in the pilot (Hedayati Mehdiabadi et al. 2019), for this paper, we focused on the activity questions most closely aligned with our research questions. Specifically, we analyzed the following activity questions concerning our three areas of interest:

- Personal identity questions in the pre-class activity:
    - In the video (around the 3:45-3:50 mark), Professor Page describes people as a “vector of skills, experiences, and talents.” What are some of the skills, experiences, and talents that make up your vector?

  - What is one aspect of your identity that might lead you to approach problems in a different way from your peers (i.e., something that makes you cognitively diverse from other engineering students you know?), and why?
- Engineering as a profession question in the post-class activity:
  - Did what you learned in this assignment change your views on the roles and responsibilities of engineers? If so, how?
- Student reported learning question in the post-class activity:
  - What did you learn from this assignment?

We used thematic analysis to analyze our data (Braun and Clarke 2006). Thematic analysis is a specific qualitative analysis method that captures themes or patterns of responses within the data relevant to the research question (Braun and Clarke 2006). This method allowed us to distill students' thoughts and ideas from their written work into overarching themes (Braun and Clarke 2006). Before our analysis, we categorized responses by research question, as shown above. We analyzed responses to each category (i.e., personal identity, engineering as a profession, and student reported learning) separately, as we postulated that the themes in each category might be different. As student responses were short answers, we coded each student's response to a particular question in its entirety.

When analyzing responses in each category, we followed the following steps in our analysis, as specified in Braun and Clarke(2006): 1) both coders collaboratively developed potential deductive codes, based on the themes identified in the pilot study and our research questions; 2) the primary coder and first author coded all student responses both inductively and deductively; 3) both coders together discussed this initial code set and the data; 4) the two coders collapsed and refined the codes; 5) using the refined codes, both coders coded 20% of the data, compared codes, and discussed any discrepancies in the coding; 6) using these further refined codes, the primary coder re-coded all of the data; 7) after final coding, the two coders discussed the data and distilled the codes into overarching themes. Codes were collapsed into themes when both coders agreed that the codes were clearly part of a larger umbrella theme. For example, different codes that all related to teamwork skills were collapsed into a single theme. The two coders' inter-rater reliability was greater than 80% for all codes after initial coding and 100% following discussion of all coding discrepancies (Merriam 2002).

Results

All students wrote about both engineering-related and more broadly applicable topics in their responses to each area of research interest (student's own identity, engineering as a profession, and student perceived learning). Overarching themes across categories were: 1) Teamwork and 2) Engineering/ math-related skills/experiences. Diversity and Inclusion was a common theme for all categories except for how students thought of engineering as a profession, as shown in the subsequent description of the individual prompts.

Student's Own Identity

When discussing characteristics that make up their own identity and that influence their approach to problem solving (pre-class questions 1 and 2, Appendix A), students wrote about math/engineering-oriented characteristics, skills, and experiences; characteristics beyond math and engineering (e.g. sports, hobbies, and life experiences); and skills and characteristics that are broadly applicable, such as teamwork and communication skills. We grouped math and physical science-related comments with engineering because most students taking Statics are in their sophomore year and likely have spent more time in math and science courses than in strictly engineering courses. The themes found in student responses are listed in Table 1, including a description of the theme, example student responses, and the percent of student responses that addressed the theme. All students included at least one characteristic in their responses that was not specific to math or engineering. Students most commonly wrote about personal attributes (61%); engineering and math-related academics, skills, and experiences (56%); teamwork and communication skills and experiences (49%); and other types of academics, skills, and experiences (49%). Thirty-three percent of students wrote about diversity (broadly defined, see Table 1 for definition), 33% also connected their personal identity to problem-solving, and 12% mentioned a personal weakness. Of the 33% of students who connected their personal identity to problem solving, 42% had only socially dominant identities in their university-reported demographics (i.e., from the university reported statistics, those who were white, male, and not-first generation). Therefore 58% of those who made the connection had at least one university-reported marginalized identity, while overall, 52% of the students who responded to the question in any way had at least one reported marginalized identity.

In comparison, 49% of those with only socially dominant identities responded to the question but did not connect their personal identity to problem solving, and 51% of those with at least one university-reported marginalized did not make a connection. Therefore, it was not only students whom the university would identify as having marginalized identities who discussed their identities. However, students usually write about an identity that they felt made them unique from the majority-experience, such as having a twin, having a sibling with a disability, growing up in a community much different from their peers, or having a family member be diagnosed with cancer. However, this analysis is limited, as it only includes binary gender, a combined race/ethnicity category, and first-generation status. Therefore, it does not include international students, those with lower socioeconomic status, and many other identities or situations that influence students' experiences. Additionally, because gender is collected as a binary by the university, the queer student in Table 1 would not be captured by the university's current reporting practices. Only 2% of students were critical of diversity either as unimportant or that thinking differently did not constitute diversity.

Students wrote nearly equally about both engineering-related (56% of students) and other academics and skills (49%; Figure 1). Students who wrote about math and engineering-related skills and experiences were more likely to write about academics (33% of all students or 60% of those who wrote about math & engineering). In contrast, when students wrote about skills and experiences unrelated to math and engineering (e.g., sports and hobbies), they more commonly wrote about experiences and skills outside academia (44% of all students or 88% of those who wrote about other academics and skills). A similar percentage of students wrote about both skills and academics in both categories (10-11%).

Even though our problem solving prompt explicitly asked students to connect their identity to problem solving, "What is one aspect of your identity that might lead you to approach problems differently from your peers (i.e., something that makes you cognitively diverse from other engineering students you know?), and why," only 33% of students connected their personal identity to how they solve problems. Students who connected their identity to problem solving wrote about identity in different ways. While there were some overarching themes, responses did not necessarily fall into discrete categories. Some students wrote about social identities (i.e., identity components generally collected in demographic data such as race, ethnicity, gender, sexual orientation), *"As a Hispanic woman in a field classically composed of Caucasian men I feel I have to work harder to prove myself, giving me the perspective of minorities. Additionally growing up in a lower-middle class home gives me perspective to the working class and lower income homes."* Others focused on identity components that were formed by common experiences they held with a larger group that may or may not relate to social identity, such as where they grew up, *"I grew up in the Middle East which has impacted the way I think and approach problems compared to people born and raised in the U.S.*". Additionally, some students focused on more personal experiences, such as those of being in a particular family, *"I think I have more hands on experience than other students because my dad owns a construction company. This can lead to different train of thought about a structure."*

Students who did not connect an aspect of their identity to problem solving (67%), commonly wrote about how they approach problems, such as looking at the big picture or focusing on the end goals and working backwards, *"I like to find the easiest way to get things done, so in a* *problem I might think of something maybe not quite as practical but rather something that will speed up the project."* Only one student rebuffed the prompt, stating, *"I just think differently than my friends. Everyone thinks differently in my opinion. I would not call this being diverse but it does lead to a better overall team."*

Engineering as a profession

Regarding how they think about the roles and responsibilities of engineering as a profession in their post-activity response, students wrote both about having their views changed and having existing views reinforced, as shown in Table 2 and Figure 2. In both cases, their responses fell into two primary overarching themes: specific team skills and characteristics that are important for engineers to have (39%) and, teamwork is essential in engineering (35%). In both themes, the number of students who wrote about their views changing and the number of students who said their views were reinforced were roughly equal (Figure 2). Twenty percent of the students wrote that their views did not change and did not provide any additional information, and 7% of students wrote about technical skills. The majority of students who wrote about technical skills wrote about things they learned, rather than views that were reinforced. Compared to responses to other questions, notably low were the 6% of responses related to the importance or benefits of diversity. Of these responses, only one student (0.6%) discussed having their views changed to connect diversity and inclusion to the engineering profession; the other eight students already held views that diversity was essential to engineering. Additional, but rare, themes (<3% of responses in a given theme) discussed ideas that were more "stereotypically" engineering, such as that engineers are used to working alone or that they think similarly, and also included students who were critical of the importance of diversity.

Students' perceptions of learning

Students' responses about what they learned from the activity fell into three main overarching themes: 1) teamwork benefits (39%) and challenges (27%), 2) application of technical skills (26%), and 3) inclusion (15%) and diversity (11%). Few, 5% or less per theme, wrote that they did not learn much or wrote about negative aspects of diversity. Only 1% directly connected teamwork and engineering by writing about the importance of teamwork in engineering (Table 3). Therefore, students reported learning both about diversity, team skills, and technical content, and few students were pessimistic about the activity.

Discussion

We sought to analyze the impact of a new teamwork activity in Statics within the framework of inclusive professional identities by studying how students related their own identities to engineering, students' understanding of the nature of engineering as a profession, and what students reported learning from the activity. From the individual question analysis, three overarching themes that reoccurred across multiple question responses included: 1) teamwork, 2) engineering/math/technical related, and 3) diversity and inclusion. Across all responses, students wrote about a range of topics. They did not merely focus on responses clearly and directly related to math and or technical aspects of engineering, indicating that they were not solely focused on engineering as a technical-only discipline (Cech and Sherick 2015). In this discussion, we focus on the connections students made from diversity and inclusion into engineering practice. Additionally, we reflect on the feasibility of this assignment type to meet project objectives.

Connecting Diversity and Engineering

The low number of responses that directly connected diversity or inclusion to engineering (n=8 or 6%), as well as the failure by most students (67%), after an explicit prompt, to connect aspects of their identity to their problem solving strategies, may indicate a critical gap to be addressed in educating engineers. Even though only a few students directly wrote about identity as irrelevant, *"our team was the most diverse team there but that didn't matter, only our knowledge of statics did,"* and we did not have any instances of our activity backfiring significantly (Rottmann and Reeve 2020), students needed more help to connect diversity and their own identities to the engineering profession. As this activity is intended to be part of a series of DEI activities, these results clarify that students need precursor or follow-up activities to make this connection. This connection of diversity to identity is vital for forming an inclusive professional identity and will likely help move engineering beyond a depoliticized profession without sociocultural complexities (Atadero et al. 2018; Cech and Sherick 2015).

Helping students acknowledge and understand their own identities is crucial in acting in inclusive and equitable ways and, therefore, developing inclusive professional identities. Students cannot address diversity-rooted issues if they do not first understand how identity and diversity influence daily experiences (Douglas 2019). This deeper work speaks to the importance of diversity and inclusion work within and beyond engineering classrooms. While the activity described in this paper made progress toward our goals, it is not nearly direct enough to address racism, sexism, ableism, classism, heterosexism, and other “isms” in our society. We recommend that other activities directly addressing deeply entrenched societal biases be implemented as well. Collectively, these activities may be a vital bridge to help students connect issues such as racism and white privilege with the engineering profession and their professional engineering identities, with the broader goal of creating a holistic engineering perspective.

In many engineering classrooms, most students are still white heterosexual, cisgender men, who have the privilege of dominant identities not only in engineering but in the broader U.S. culture. Students with marginalized identities are often forced to navigate a complicated relationship between their professional identities and their own marginalized identities (Hughes 2017). In contrast, students with dominant identities are less likely to spend time introspecting their identities. In our study, nearly half of the students who connected their identity to problem solving did not have a university-reported marginalized identity, indicating that it encouraged students with dominant identities to be more introspective. Therefore, activities that dig deeper into identity and those that intentionally address identity within the engineering curriculum are needed and may help students who do not have university-reported marginalized identities think more in-depth about their own identities. By adding identity-based activities to engineering courses, we can promote the thinking that the things students learn about themselves through introspection are relevant to how they move through their engineering major and profession.

While students overwhelmingly wrote in ways that conceptualized engineering as more inclusive and expansive than common stereotypes, they rarely connected engineering to the importance of diversity when discussing the profession of engineering (Table 2). Possibly, the short responses we collected were not targeted enough to collect this type of student response. However, it may also be because students need more explicit guidance on connecting diversity and inclusion to the profession of engineering. This missed connection could indicate the importance of diversity-oriented activities to exemplify how diversity and inclusion relate to engineering and highlights the need to analyze student answers for both what is included and excluded from their responses.

Possible Enhancements to the Assignment

Although a single assignment cannot be expected to change student views of diversity and inclusion in engineering fully, the instructor and research team have some ideas about how the activity could be modified to meet this learning objective better. First, while the problem was framed as a "design" problem, the design was very constrained, leading to a single correct answer. One way diverse viewpoints can contribute to better problem-solving outcomes is differences in how problems are understood or interpreted (Page 2016). This assignment could be modified by providing a beam sizing scenario where the applied load is not specified. For example, if students were asked to size the cross-beam for a swing set that should serve four users, students would need to think for themselves about the types of users they expect to use the swing set and establish loads. Each group would likely develop a distinct design, and after students completed their design, a series of reflection questions could be used to help students think about the assumptions the group made about the swing users and how diverse life experiences had (or had not) influenced the group's expectations about the riders. Specific questions could ask about the ability of the swing set to support, for example, adaptive swings or overweight parents swinging with their children.

Another way this assignment could be revised is to include a class discussion component. The discussion could occur after students watch and respond to the video, but before they work in groups. Full class discussions can be difficult in high-enrollment courses, such as the Statics courses used in this study, but the instructor could provide careful prompts for students to discuss in smaller groups. For example, the instructor could look over student responses to the video and ask questions intended to develop student understanding of the connections between diversity and engineering a little further. This approach would require the instructor to be more comfortable discussing diversity and inclusion issues in class and would require class time for the discussion.

Making Diversity Curriculum Relevant and Feasible in Any Major

University and college level diversity initiatives are becoming increasingly common; however, translating these initiatives into meaningful course content is difficult. Even when instructors value diversity and think diversity-oriented content leads to better classroom outcomes, these values do not necessarily translate into classroom practices (Mayhew and Grunwald 2006). Our intervention provides one example of how to take steps towards integrating diversity-oriented content into a technical engineering course to meet technical learning goals and potentially make progress towards diversity-oriented learning goals. By embedding diversity content into technical activities, students are presented with material that connects diversity and engineering, making diversity relevant to their course of study and not merely an outside add-on (Hartman et al. 2019).

Our students' responses indicate that they mostly responded well to the activity. It encouraged them to conceptualize engineering more broadly and value a wide range of skills and attributes when thinking about how they contribute to engineering and related problem solving (Tables 1-3). This positive response supports the notion that contextualized course activities support all students' learning, particularly those who are often marginalized in engineering (Estrada et al. 2016). As our activity also asked students to identify characteristics and attributes they bring to engineering, this work should also help promote student success (Jordt et al. 2017; Miyake et al. 2010; Shnabel et al. 2013). Because the activity primed them to think about and place value on diversity, we cannot know if some students simply wrote what they thought we wanted to hear. At the same time, even if students are skeptical, this activity provided external reinforcement from their professor of the value of diversity and teamwork, components that are often missing from technical-oriented engineering education.

The need for diversity and inclusion oriented activities

Given that most students discussed the importance of teamwork and inclusion on teams and linking aspects of their identity (not directly related to engineering) to their personal "toolbox" of skills and attributes, our intervention appears to have been useful. However, the handful of student responses explicitly demonstrating values counter to diversity and inclusion indicate the importance of diversity and inclusion-focused course activities throughout the engineering curriculum. These responses, such as those that did not see the value of diversity, thought that engineers thought similarly, or thought that engineers are better at working alone (Tables 1 and 2), indicate well-entrenched stereotypes within engineering fields (Cheryan, Master, and Meltzoff 2015). Stereotypical responses such as these indicate further work needs to be done to counter those stereotypes. Diversity and inclusion activities throughout the engineering curriculum may help change these views.

Students' responses that indicate difficultly in valuing diversity are sometimes more nuanced than those that are more outright in their claims that diversity is irrelevant. This nuance supports the need for course activities that teach about and reinforce the importance of diversity, equity, and inclusion in engineering. Responses, such as *"[my] group was too homogenous to learn much"* and *"I'm not so sure I am different than my peers. After all we are all in the same college chasing the* *same goal. The way I see it, we are all the same…. I think that in this respect the term diversity has little relevance to working in teams,"* may indicate multiple areas for concern. These areas include lack of diversity in engineering programs, students not being aware of the different types of diversity their groups, or "colorblind" socialization which emphasizes the similarities of people and downplays their differences. Responses such as *"No. Our team was the most diverse team there but that didn't matter, only our knowledge of Statics did,"* indicate a viewpoint of erasing diversity. This viewpoint is now considered outdated and is problematic because it ignores the diversity of personal experiences. These types of societal embedded power and privilege dynamics can only be addressed if we acknowledge their presence (Tarca 2005). Activities that more explicitly problematize perspectives that downplay differences and erase diversity may be needed to help address these types of perspectives.

Limitations

While our results provide a pathway for integrating diversity-oriented content into technical engineering courses, our study does have some limitations. The results from this study are from a two sections of a single class, although similar results are supported by our pilot data collected in the same class in the previous year (Hedayati Mehdiabadi et al. 2019). Our student learning data are based on students' self-reporting, and are from shortly after completing the activity, so we do not know how long lasting the impacts are. Additionally, our demographic data are limited by what and how the data are collected by the university. It is also possible that critical students were less likely to consent to have their work analyzed, changing our results. Since valuing diversity and inclusion were clear learning objectives from the activity, it is also impossible to know if students were simply "parroting" the clear "right answer" or if they believed what they were writing.

Conclusions

The jigsaw and related activities presented herein demonstrate that students are responsive to diversity-oriented content and that they appear to be learning in ways that achieve technical, teamwork, and diversity learning goals. Few students were critical of the diversity component of the activity and we did not any other indications of the activity causing a backfire effect. Based on student responses from other course activities that we have developed that are part of a more extensive study, a small percentage of students will criticize these types of activities. This criticism is to be expected, considering that some segments of society often consider diversity and inclusion to be specialized agendas. However, as described above, these views are symptoms of current societal inequities and rationale for the need for these kinds of activities, rather than reasons to avoid them. While some students may have their inequitable views entrenched by this course activity, we believe most students' growth is worth this potential downside. Further infusion of diversity- and inclusion-focused course material is likely necessary to help undergraduate engineering students connect these vital topics to engineering and develop inclusive professional identities and values. Future work to integrate diversity and inclusion activities into technical STEM classes can contribute to this growing body of knowledge by providing longer-term analysis of student learning, measuring student learning through pre-post tests, and developing additional interventions across multiple STEM content areas.

Appendix A: Pre-class questions, for the video *Why the best people don't mean the best teams* (Page 2016)**.**

1. In the video (around the 3:45-3:50 mark) Professor Page describes people as a "vector of skills, experiences, and talents". What are some of the skills, experiences and talents that make up your vector?
2. What is one aspect of your identity that might lead you to approach problems in a different way from your peers (i.e. something that makes you cognitively diverse from other engineering students you know?), and why?
3. What type of group is best suited to solving complex problems? Why is this type of group particularly important in the modern world?

4. At the end of the video, Professor Page talks about how diverse teams can produce the best work, but in some cases can also produce very poor work. The diversity of the team will only benefit the product if the team members can work together effectively. How can we set up environments so that there are optimal interactions among group members? In other words, what can professors do in the classroom or what can YOU do in a group setting so that your team is making the most of group work?

Appendix B: Questions following the in-class component

After the in-class activity students were asked to complete the following five questions to evaluate the activity's impact:

1. What did you learn from this assignment?
2. Think about interacting with other engineering students, especially those who are different from you. How can you apply what you learned to your interactions?
3. Did what you learned in this assignment change your views on the roles and responsibilities of engineers? If so, how?
4. What did you like about this assignment?
5. What would you change about this assignment to make it more engaging for you?

Data Availability

Some or all data, models, or code generated or used during the study are proprietary or confidential in nature and may only be provided with restrictions. Due to the nature of this research, participants of this study did not agree for their data to be shared publicly and the privacy of the data is protected by IRB requirements, so supporting data is not available.

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References

American Society of Engineering Education. 2019. ASEE Best Diversity Paper Past Winners. 2019. https://diversity.asee.org/deicommittee/best-paper-past/.

Atadero, Rebecca A., Christina H. Paguyo, Karen E. Rambo-Hernandez, and Heather L. Henderson. 2018. "Building Inclusive Engineering Identities: Implications for Changing Engineering Culture." *European Journal of Engineering Education* 43 (3): 378–98. https://doi.org/10.1080/03043797.2017.1396287.

Bartilla, Anne, and Christian Köppe. 2015. "Awareness Seeds for More Gender Diversity in Computer Science Education." In *Proceedings of the 20th European Conference on Pattern Languages of Programs - EuroPLoP '15*, 1–11. Kaufbeuren, Germany: ACM Press. https://doi.org/10.1145/2855321.2855359.

Bell, Derrick A. 1980. "Brown v. Board of Education and the Interest-Convergence Dilemma." *Harvard Law Review* 93 (3): 518. https://doi.org/10.2307/1340546.

Bilimoria, Diana, and Abigail J Stewart. 2009. "'Don't Ask, Don't Tell': The Academic Climate for Lesbian, Gay, Bisexual, and Transgender Faculty in Science and Engineering." *NWSA Journal* 21 (2): 85–103.

Braun, Virginia, and Victoria Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3 (2): 77–101. https://doi.org/10.1191/1478088706qp063oa.

Casper, A M Aramati, Katherine Ray King, Rebecca Atadero, and Linda C Fuselier. 2020. "Revealing the Queer-Spectrum in STEM: Undergraduate Student Responses to Diverse Gender Identity and Sexual Orientation Demographics Questions." In . Portland, Oregon. https://mountainscholar.org/handle/10217/201606.

Cech, E. A. 2015. "LGBT Professionals' Workplace Experiences in STEM-Related Federal Agencies." In *2015 ASEE Annual Conference and Exposition Proceedings*, 26.1094.1-26.1094.10. Seattle, Washington: ASEE Conferences. https://doi.org/10.18260/p.24431.

Cech, E. A., and Michelle Pham. 2017. "Queer in STEM Organizations: Workplace Disadvantages for LGBT Employees in STEM Related Federal Agencies." *Social Sciences* 6 (1): 12. https://doi.org/10.3390/socsci6010012.

Cech, E. A., and William R. Rothwell. 2018. "LGBTQ Inequality in Engineering Education." *Journal of Engineering Education* 107 (4): 583–610. https://doi.org/10.1002/jee.20239.

Cech, E. A., and Heidi M. Sherick. 2015. "Depoliticization and the Structure of Engineering Education." In *International Perspectives on Engineering Education*, edited by Steen Hyldgaard Christensen, Christelle Didier, Andrew Jamison, Martin Meganck, Carl Mitcham, and Byron Newberry, 20:203–16. Philosophy of Engineering and Technology. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-16169-3_10.

Cech, E. A., and Tom J. Waidzunas. 2011. "Navigating the Heteronormativity of Engineering: The Experiences of Lesbian, Gay, and Bisexual Students." *Engineering Studies* 3 (1): 1–24. https://doi.org/10.1080/19378629.2010.545065.

Cheryan, Sapna, Allison Master, and Andrew N. Meltzoff. 2015. “Cultural Stereotypes as Gatekeepers: Increasing Girlsâ€™ Interest in Computer Science and Engineering by Diversifying Stereotypes.” *Frontiers in Psychology* 6 (February). https://doi.org/10.3389/fpsyg.2015.00049.

Chi, Michelene TH, and R. D. Roscoe. 2002. “The Processes and Challenges of Conceptual Change.” In *Reconsidering Conceptual Change*, by M. Limon and L. Mason, 3–27. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Committee on Equal Opportunities in Science and Engineering. 2004. “Broadening Participation in America’s Science and Engineering Workforce: The 1994-2003 Decennial & 2004 Biennial Reports to Congress.” CEOSE 04-01. Arlington, Virginia: National Science Foundation.

———. 2015. “CEOSE 2013-2014 Biennial Report to Congress: Broadening Participation in America’s STEM Workforce.” CEOSE 15-01. https://www.nsf.gov/od/oia/activities/ceose/reports/Full_2011-2012_CEOSE_Report_to_Congress_Final_03-04-2014.pdf.

Cullinane, J., and L.H. Leewater. 2009. “Diversifying the STEM Pipeline: The Model Replication Institutions Program.” Institute for Higher Education Policy. www.ihep.org/sites/default/files/uploads/docs/pubs/ report_diversifying_the_stem_pipeline_report.pdf.

Darner, Rebekka. 2019. “How Can Educators Confront Science Denial?” *Educational Researcher* 48 (4): 229–38. https://doi.org/10.3102/0013189X19849415.

Douglas, Jude. 2019. “Working with Gender in Transformative Education and Supervision: Unpacking the Invisible Handbag.” *Aotearoa New Zealand Social Work* 31 (1): 49. https://doi.org/10.11157/anzswj-vol31iss1id535.

Eliot, Matt, and Jennifer Turns. 2011. “Constructing Professional Portfolios: Sense-Making and Professional Identity Development for Engineering Undergraduates.” *Journal of Engineering Education* 100 (4): 630–54. https://doi.org/10.1002/j.2168-9830.2011.tb00030.x.

Estrada, Mica, Myra Burnett, Andrew G. Campbell, Patricia B. Campbell, Wilfred F. Denetclaw, Carlos G. Gutiérrez, Sylvia Hurtado, et al. 2016. “Improving Underrepresented Minority Student Persistence in STEM.” Edited by Pat Marsteller. *CBE—Life Sciences Education* 15 (3): es5. https://doi.org/10.1187/cbe.16-01-0038.

Freire, Paulo. 2000. *Pedagogy of the Oppressed*. 30th anniversary ed. New York: Continuum.

Garces, Liliana M., Ann M. Ishimaru, and Sola Takahashi. 2017. “Introduction to Beyond Interest Convergence: Envisioning Transformation for Racial Equity in Education.” *Peabody Journal of Education* 92 (3): 291–93. https://doi.org/10.1080/0161956X.2017.1324654.

Gill, Judith, Rhonda Sharp, Julie Mills, and Suzanne Franzway. 2008. “I Still Wanna Be an Engineer! Women, Education and the Engineering Profession.” *European Journal of Engineering Education* 33 (4): 391–402. https://doi.org/10.1080/03043790802253459.

Godwin, Allison, Adam Kirn, and Jacqueline A Rohde. n.d. “Awareness Without Action: Student Attitudes Toward Team Diversity after Engineering Teaming Experiences,” 14.

Gordon, Sarah R, Mike Yough, Emily A Finney, Andrea Haken, and Susan Mathew. 2019. “Learning about Diversity Issues: Examining the Relationship between University Initiatives and Faculty Practices in Preparing Global-Ready Students.” *Educational Considerations* 45 (1): 19.

Gordon, Sarah R., Mike Yough, Emily A. Finney-Miller, Susan Mathew, Andrea Haken-Hughes, and Jati Ariati. 2021. “Faculty Perceptions of Teaching Diversity: Definitions, Benefits, Drawbacks, and Barriers.” *Current Psychology*, February. https://doi.org/10.1007/s12144-021-01406-2.

Gutierrez, K, C. H. Paguyo, and E. Mendoza. 2012. “Essentializing Racial and Ethnic Identity.” In *Encyclopedia of Diversity in Education*, edited by J. Banks. Vol. 2. Thousand Oaks, CA: Sage Publishers.

Hartman, Harriet, Tiago Forin, Beena Sukumaran, Stephanie Farrell, Parth Bhavsar, Kauser Jahan, Ralph Dusseau, et al. 2019. “Strategies for Improving Diversity and Inclusion in an Engineering Department.” *Journal of Professional Issues in Engineering Education and Practice* 145 (2): 04018016. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000404.

Hedayati Mehdiabadi, D, Rebecca A. Atadero, Dan W. Baker, and Anne Marie Aramati Casper. 2019. “The Effects of Infusing Diversity and Inclusion into a Design Problem in Engineering Mechanics: Statics.” In *American Society for Engineering Education Conference, Tampa, Florida*. Tampa, Florida.

Hernandez, Jesus. 2014. “Race, Market Constraints, and the Housing Crisis: A Problem of Embeddedness.” *Kalfou: A Journal of Comparative and Relational Ethnic Studies* I (2): 29–58. https://doi.org/10.15367/kf.v1i2.31.

Hernández-de-Menéndez, Marcela, Antonio Vallejo Guevara, Juan Carlos Tudón Martínez, Diana Hernández Alcántara, and Ruben Morales-Menendez. 2019. “Active Learning in Engineering Education. A Review of Fundamentals, Best Practices and Experiences.” *International Journal on Interactive Design and Manufacturing (IJIDeM)* 13 (3): 909–22. https://doi.org/10.1007/s12008-019-00557-8.

Hong, L., and S. E. Page. 2004. “Groups of Diverse Problem Solvers Can Outperform Groups of High-Ability Problem Solvers.” *Proceedings of the National Academy of Sciences* 101 (46): 16385–89. https://doi.org/10.1073/pnas.0403723101.

Hughes, Bryce E. 2017. “‘Managing by Not Managing’: How Gay Engineering Students Manage Sexual Orientation Identity.” *Journal of College Student Development* 58 (3): 385–401. https://doi.org/10.1353/csd.2017.0029.

Hunt, Vivian, Dennis Layton, and Sara Prince. 2015. “Diversity Matters.” McKinsey & Company.

Ihsen, Susanne, and Sabrina Gebauer. 2009. “Diversity Issues in the Engineering Curriculum.” *European Journal of Engineering Education* 34 (5): 419–24. https://doi.org/10.1080/03043790903137551.

Jordt, Hannah, Sarah L. Eddy, Riley Brazil, Ignatius Lau, Chelsea Mann, Sara E. Brownell, Katherine King, and Scott Freeman. 2017. “Values Affirmation Intervention Reduces Achievement Gap between Underrepresented Minority and White Students in Introductory Biology Classes.” Edited by Jeff Schinske. *CBE—Life Sciences Education* 16 (3): ar41. https://doi.org/10.1187/cbe.16-12-0351.

Koretsky, Milo D, Devlin Montfort, Susan Bobbitt Nolen, Michelle Bothwell, Susannah C Davis, and James D Sweeney. 2018. “TOWARDS A STRONGER COVALENT BOND: PEDAGOGICAL CHANGE FOR INCLUSIVITY AND EQUITY.” *Chemical Engineering Education* 52 (2): 11.

LaFave, James M., Hyun-Sook Kang, and Jeremy David Kaiser. 2015. “Cultivating Intercultural Competencies for Civil Engineering Students in the Era of Globalization: Case Study.” *Journal of Professional Issues in Engineering Education and Practice* 141 (3): 05014008. https://doi.org/10.1061/(ASCE)EI.1943-5541.0000234.

Leicht-Scholten, Carmen, Asli-Juliya Weheliye, and Andrea Wolffram. 2009. “Institutionalisation of Gender and Diversity Management in Engineering Education.” *European Journal of Engineering Education* 34 (5): 447–54. https://doi.org/10.1080/03043790903137700.

Lemke, Jay L. 2001. “Articulating Communities: Sociocultural Perspectives on Science Education.” *Journal of Research in Science Teaching* 38 (3): 296–316.

Mayhew, Matthew J., and Heidi E. Grunwald. 2006. “Factors Contributing to Faculty Incorporation of Diversity-Related Course Content.” *The Journal of Higher Education* 77 (1): 148–68. https://doi.org/10.1353/jhe.2006.0005.

Merriam, Sharan B. 2002. *Qualitative Research in Practice: Examples for Discussion and Analysis*. 1st ed. The Jossey-Bass Higher and Adult Education Series. San Francisco: Jossey-Bass.

Miyake, A., L. E. Kost-Smith, N. D. Finkelstein, S. J. Pollock, G. L. Cohen, and T. A. Ito. 2010. “Reducing the Gender Achievement Gap in College Science: A Classroom Study of Values Affirmation.” *Science* 330 (6008): 1234–37. https://doi.org/10.1126/science.1195996.

National Science Foundation, National Center for Science and Engineering Statistics. 2019. “Women, Minorities, and Persons with Disabilities in Science and Engineering.” Special Report NSF 19-304. Alexandria, VA. https://www.nsf.gov/statistics.

National Society of Black Engineers. 2016. “NSBE: National Society of Black Engineers.” https://nsbe.org/home.aspx.

Ochoa, G. L., and D. Pineda. 2008. “Deconstructing Power, Privilege, and Silence in the Classroom.” *Radical History Review* 2008 (102): 45–62. https://doi.org/10.1215/01636545-2008-012.

Page, Scott E. 2007. *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies*. 3. printing, 1. pbk. printing. Princeton, NJ: Princeton Univ. Press.

———. 2016. *Why the Best People Don’t Mean the Best Teams*. https://www.youtube.com/watch?v=wULRXoYThDc.

Park, Julie J., and Nida Denson. 2009. “Attitudes and Advocacy: Understanding Faculty Views on Racial/Ethnic Diversity.” *The Journal of Higher Education* 80 (4): 415–38. https://doi.org/10.1080/00221546.2009.11779023.

Peixoto, Aruquia, Carina Soledad Gonzalez Gonzalez, Rebecca Strachan, Pedro Plaza, Maria de los Angeles Martinez, Manuel Blazquez, and Manuel Castro. 2018. “Diversity and Inclusion in Engineering Education: Looking through the Gender Question.” In *2018 IEEE Global Engineering Education Conference (EDUCON)*, 2071–75. Tenerife: IEEE. https://doi.org/10.1109/EDUCON.2018.8363494.

Pew Research Center. 2018. “Women and Men in STEM Often at Odds over Workplace Equity.” https://www.pewsocialtrends.org/2018/01/09/women-and-men-in-stem-often-at-odds-over-workplace-equity/.

Rasmussen, Tina. 2007. *Diversity Mosaic: The Complete Resource for Establishing a Successful Diversity Initiative*. San Francisco, CA: Pfeiffer.

Riley, Donna. 2003. “Employing Liberative Pedagogies in Engineering Education.” *Journal of Women and Minorities in Science and Engineering* 9 (2): 137–58. https://doi.org/10.1615/JWomenMinorScienEng.v9.i2.20.

Rottmann, Cindy, and Douglas Reeve. 2020. “Equity as Rebar: Bridging the Micro/Macro Divide in Engineering Ethics Education.” *Canadian Journal of Science, Mathematics and Technology Education* 20 (1): 146–65. https://doi.org/10.1007/s42330-019-00073-7.

Shnabel, Nurit, Valerie Purdie-Vaughns, Jonathan E. Cook, Julio Garcia, and Geoffrey L. Cohen. 2013. “Demystifying Values-Affirmation Interventions: Writing About Social Belonging Is a Key to Buffering Against Identity Threat.” *Personality and Social Psychology Bulletin* 39 (5): 663–76. https://doi.org/10.1177/0146167213480816.

Smit, Renee´. 2012. “Towards a Clearer Understanding of Student Disadvantage in Higher Education: Problematising Deficit Thinking.” *Higher Education Research & Development* 31 (3): 369–80. https://doi.org/10.1080/07294360.2011.634383.

Society of Hispanic Professional Engineers. 2020. “SHPE: Leading Hispanics in STEM.” https://www.shpe.org/.

Society of Women Engineers. 2020. “Society of Women Engineers: A Catalyst for Change.” https://swe.org/.

Sólorzano, Daniel G., Octavio Villalpando, and Leticia Oseguera. 2005. “Educational Inequities and Latina/o Undergraduate Students in the United States: A Critical Race Analysis of Their Educational Progress.” *Journal of Hispanic Higher Education* 4 (3): 272–94. https://doi.org/10.1177/1538192705276550.

Su, Lester K. 2010. "Quantification of Diversity in Engineering Higher Education in the United States." *Journal of Women and Minorities in Science and Engineering* 16 (2): 15.

Tarca, Katherine. 2005. "Colorblind in Control: The Risks of Resisting Difference Amid Demographic Change." *Educational Studies* 38 (2): 99–120. https://doi.org/10.1207/s15326993es3802_3.

Trede, Franziska, Rob Macklin, and Donna Bridges. 2012. "Professional Identity Development: A Review of the Higher Education Literature." *Studies in Higher Education* 37 (3): 365–84. https://doi.org/10.1080/03075079.2010.521237.

Women's Engineering Society. 2019. "The Women's Engineering Society: Celebrating 100 Years." https://www.wes.org.uk/.

Table 1: Themes of students' personal identities[1]

Theme	Components	Example	%
Personal attributes	Personal attributes/characteristics	*"Tenacity, kinesthetic intuition."*	61
Engineering/ math academics, skills, and experiences	Math or engineering related academics, skills, or experiences, also includes physics and chemistry as related to engineering	*"I like utilizing math and formulas to come to a conclusion instead of merely looking at the problem trying to gauge a solution"*	56
Team building &/or group work	Skills/experiences related to working with others	*"Some of my skills include communicating within large and small groups. I have practiced this throughout high school being involved in Student Government and Poms Captain."*	49
Other academics, skills, and experiences	Academics, skills, or experiences that are not related to engineering, math, physics, or chemistry	*"I played hockey, I love to sail and do just about every water sport there is."*	49
Diversity	Diversity in some aspect, including discussing attributes usually categorized under diversity initiatives (e.g., bi/multi-lingual, living in multiple countries, gender and racial/ethnic identities, veteran status), as well as if student explicitly talks about diversity	*"As a Hispanic woman in a field classically composed of Caucasian men I feel I have to work harder to prove myself, giving me the perspective of minorities. Additionally growing up in a lower-middle class home gives me perspective to the working class and lower income homes."*	33
Connected personal identity to problem solving	As requested by the prompt, discussed how an aspect of their identity influenced their approach to problem solving	*"I am part of the Queer Community as a trans woman and that has changed the way I think about not only ethics but problem solving because I've had to manage with different sets of problems than most people."*	33

Own weakness	Personal weakness or challenge	*"I am truthfully not as proficient as others in math and it seems to take me double the time to understand topics. I struggle with topic others understand and need that extra push or that extra worksheet in order to succeed."*	12
Critical of diversity	Critical of either diversity initiatives as a whole, or discussing diversity in relationship to the activity	*"I'm not so sure I am different than my peers. After all we are all in the same college chasing the same goal. The way I see it, we are all the same…. I think that in this respect the term diversity has little relevance to working in teams."*	2

1: All percentages are the percent of students whose responses fit a given theme. Students' answers commonly included more than one theme; therefore percentages do not add up to 100.

Table 2: How this assignment influenced student views of engineering.

Theme	Description	Example Quote	%
Specific team skills and characteristics	Discussed teamwork skills or characteristics important in teamwork, includes valuing different perspectives	*"….Yet, seeing the failure of communication did tell me that engineers need to communicate effectively."*	39
Teamwork is important in engineering	Explicitly mentioned the importance of teamwork in engineering	*"This changed how I viewed engineers by making me see that it is a lot of team work instead of individual problem solving."*	35
Technical answers	Discussed a component of technical engineering	*"Engineers are responsible for the equilibrium of what they engineer and if the equilibrium breaks, it is solely from math errors."*	7
Diversity and inclusion	Specifically mentioned the importance of diversity or inclusion as part of engineering	*"... really enforced the idea of teamwork and diversity in engineering and my experiences at the Asian Pacific American Cultural Center and with the Native American and Black/African American Cultural Centers bring to focus how important diversity is in life in general."*	6
No change, no specifics	Wrote that nothing changed and did not specify anything else	*"No it did not change my view on how engineers function or their roles."*	20
Engineers are used to working alone	Engineers like to work alone	*"I noticed that the majority of Engineers tend to like to work on things in their own way and at their own pace."*	1
Engineers think similarly	Engineers think about things in similar ways	*"… engineers have similar approaches to solving problems and this emits from the common way of learning and teaching."*	1

Critical of Diversity	Was critical of diversity or its importance, either as a whole or in the project	*"Yes, there tends to be more or less educated group members and the more educated ones tend to lead the group while the less benefit from soaking in all the information."* *"No. Our team was the most diverse team there but that didn't matter, only our knowledge of Statics did."*	1
Needed more time	Not enough time to complete/work on	*"…I feel like no one knew what they were doing until the last few min of class, at which point there was little we could do."*	1
Group too homogenous	Homogeneity of the group either limited discussing work in relationship to diversity or was generally problematized	*"Group was too homogenous to learn much."*	0.5

Table 3: Students' reported learning gains from the activity

Theme	Description	Example	%
Teamwork benefits and skills	Mentioned a benefit or skill related to teamwork	*"It helped me learn how to work in groups and consider other ideas for the best outcome."*	39
Challenges of teamwork	Discussed teamwork in terms of challenges	*"I learned that to work well with a team, everyone has to know what to do. When a person is not as knowledgeable as others, it lends itself to one person doing the majority of the work"*	27
Technical knowledge/skills, including their real-world application	Specific technical knowledge/skills or applying these technical skills	*"More about shear and moment diagrams."*	26
Benefits of diversity	Discussed diversity in terms of benefits	*"It's important to have as many different people with different backgrounds and perspectives as possible in order to form the most successful team."*	15
Inclusion	Including all group members, such as resultant benefits	*"I learned that it's valuable to listen to everyone's input because you never know whose info might help you the most."*	11
Did not learn much	Why they didn't learn or learn much from the activity	*"Unfortunately I did not learn a whole lot from this assignment. The idea of designing the beams required for this crane were interesting to me however my team seemed to lack the same interest that I had."*	5
Negative about diversity	Discussed a negative aspect of diversity	*"However managing diversity is still a challenge, and time consuming."*	2
Teamwork in engineering	Discussed teamwork specifically as	*"I learned that teamwork is an important aspect to engineering"*	1

	important in engineering		
Other		*"Most of my other group members had different ideas for how the problem should be approached. I also think this is because we were all given different background information that was supposed to signify diversity in perspectives."* *"I learned that you should not trust college students to pick out an appropriate beam in 50 minutes."*	1

Figure Captions

Figure 1: Students wrote about both engineering-related and other academics and skills.

Figure 2: How students' perspectives about the engineering profession either changed or were reinforced.