More than Recruitment and Outreach: Diversity and Inclusion in Engineering Education Curricula and Classrooms

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Abstract

In engineering education, diversity and inclusion may be buzzwords, but the overall focus tends to be diversity and *integration*, placing the burden of change and knowledge-building on underrepresented individuals and groups. The result is the "leaky pipeline," where an increase in majors from underrepresented groups does not cause an increase in engineering workplace diversity or impact engineering workplace culture. If engineering education makes diversity and inclusion an explicit pillar in our curricula and classrooms, there is the potential to patch the leaky pipeline by improving engineering culture for not just underrepresented groups but everyone and increase the overall diversity and strength of engineering disciplines. In particular this work-in-progress explores how an engineering education course, Engineering Technical Communications, addresses and teaches issues of diversity and inclusion and provides an exploration of how D/I can be central to engineering education curricula. (139)

Keywords (5)

Diversity and Inclusion; Curricula; Leaky Pipeline; Culture

Introduction

What might it mean to place not just diversity but also inclusion at the forefront of engineering education? Though issues of diversity and inclusion (D/I) are not new areas of concern for engineering education, explicit discussions about diversity and actions to increase diversity and foster inclusion in engineering education are relatively new. For example, the American Society of Engineering Education was formed in 1893, but ASEE's Diversity Committee was formed only 5 years ago in 2011.[1] This doesn't mean that diversity wasn't considered prior to this committee, but the formation of the committee signals a formal and explicit naming of diversity as an important issue and goal for engineering education and ASEE. This increasing importance of diversity and inclusion can be seen through a search through ASEE presentations and workshops as well, with an eightfold increase in the terms "diversity and inclusion" between 2011 and 2016, and a 1.73% increase in the term "diversity" during the same time period. Scholarship, research, and conversations about diversity and inclusion in engineering education are great steps toward increasing awareness of D/I. We must now turn from acknowledging the importance of diversity to enacting practices and curricula that foster diversity and especially *inclusion* in meaningful ways. Central to this process is identifying ways we may not only continue to increase the number of underrepresented students in engineering but also retain them both in universities and engineering workplaces. In other words, we need to fix the so-called leaky pipeline. Allen-Ramdial and Campbell in "Reimaging the Pipeline: Advancing STEM Diversity, Persistence, and Success" argue that the school-employment pipeline, similar to physical pipeline, necessitate inspections, maintenance, and at times repair or replacement when things are not work as well as they should.[2] I suggest that Engineering Education (EE) work toward repairing and replacing components of our pipeline, particularly the overall institutional and disciplinary climate and culture, by not just recruitment but by making diversity and inclusion explicit and significant components of our curricula.

Recruitment and outreach programs have been successful in increasing women and other minorities enrolled as engineering majors, but there has not been a corresponding change in the make-up of engineering workplaces.[3 4 5 6] For example, in 2015, women received 19.1% of engineering bachelor degrees, with a less than 1% fluctuation between 2006 and 2015, and approximately 35.1% of all engineering bachelors' degrees were earned by non-white individuals in 2015, an increase of less than 1% since 2006.[7] However, in 2015, women made up approximately 7.5% of the non-managerial engineering workforce, and approximately 15.3% of the non-managerial engineering workforce was African American, Asian, or Hispanic/Latino.[8] The disparities between degree attainment and employment rates within engineering fields demonstrate that more students in the education pipeline is not translating to increased umbers in the workplace.

Long and Meija argue that major factors in this leaky pipeline are "Social inequities and prejudice [which] actively drive both women and underrepresented males out of engineering and related STEM fields" (p.214).[3] If engineering education classrooms and curricula do not explicitly address and provide frameworks for understanding the relevancy of diversity and inclusion and strategies for engaging with D/I and diverse workplaces, then dominant engineering students', instructors', and institutions' implicit biases and behaviors will remain unchallenged, resulting in classrooms and workplaces that replicate long-standing inequalities and behaviors and push out underrepresented engineers. Recruitment and outreach are wasted if those recruited leave the major or profession.

Part of the issue is that the overall focus in engineering education tends to be diversity and *integration*, placing much of the burden of change and knowledge-building on underrepresented individuals and groups. Diversity is the recognition of difference, both immutable and mutable characteristics such as race, ethnicity, gender and gender identity, worldview, and more. Inclusion is the valuing and embracing of the differences in order to impact and improve the overall climate for all people. However, in practice, diversity is often followed by *integration* instead of *inclusion.* What this means is that the pressure is on the underrepresented groups to assimilate so that their behaviors, attitudes, and worldviews to match the majority.

The result of diversity and integration is the leaky pipeline, where an increase in majors from underrepresented groups does not cause an increase in engineering workplace diversity or impact engineering workplace culture. If engineering education makes diversity and inclusion an explicit pillar in our curricula and classrooms, there is the potential to repair and "enhance functionality"[2] of the pipeline by improving engineering culture for underrepresented groups and increase the overall diversity and strength of engineering disciplines. This work-in-progress suggests that recruitment and outreach continue to place the burden of effecting change on the underrepresented, placing D/I as a niche concern rather than a concern central to the success of engineering education and engineering as a whole. Instead, we must shift focus toward improving the overall climate in engineering classrooms and workplaces, beginning with engineering education curricula.

From Outreach and Recruitment to Shifting Curricula and Climate

Outreach and recruitment of underrepresented groups are necessary, but they are only the first step. Engineering programs must demonstrate a commitment to diversity and especially to inclusion of people from a wide range of backgrounds. By placing D/I as a core part the curricula, EE sends the message that D/I are not only important but also central to being a successful engineer in the 21st century. When D/I are part of the curricula, all engineering students and future engineers are provided with frameworks for understanding and valuing difference. More importantly, this move signals that D/I are central to successful engineering and a concern for all engineers not just underrepresented groups.
Long and Meija (2016) argue that we must

> evaluate how a deeper understanding of the ways in which we see diversity…can help us challenge preconceived narratives and beliefs….[and] far more attention should be paid to understanding and eliminating barriers to minority students success at the macro level (e.g., the institution, legislation) rather than just the micro level (e.g. students, teachers).[3]

In other words, we have to do more than recruit those from underrepresented groups; we must shift broader institutional approaches to D/I which includes educational policy at the national and state levels and curricula and policy at the institutional level. This means re-envisioning the STEM pipeline, as Allen-Ramdial and Campbell suggest: we must "reimagine this pipeline as a vertical structure that is subject to the laws of physics, where downward forces, such as poor or insufficient mentorship, oppose the upward flow of STEM trainee progression, resulting in STEM attrition" (p. 612).[2] The downward pressure they discuss includes attitudes and practices of majority students, instructors, and engineers that create an isolating or even hostile classroom or workplace culture and climate for non-majority individuals. This is integration-in-action: people from diverse backgrounds are part of the broader community, but they are expected to assimilate to the majority's beliefs, behaviors, and values which include shouldering the burden of being a model minority, resulting in isolation and attrition.[3]

The move from integration to inclusion requires changes at the micro and macro levels, and I contend that focusing on institutional/departmental levels will provide the framework and support for changes at the micro level. Institutional climate and culture determine how much downward pressure there is in the pipeline and therefore how likely it is that underrepresented engineers will leave the field. Allen-Ramdial and Campbell define both institutional culture and climate:

> *Institutional culture* represents the collection of shared values and belief that is the blueprint that guides actions, which inevitably establishes climate. *Institutional climate,* however, represents the practices and behaviors that determine the prevailing attitudes in the environment.[2]

In engineering education, curricula are the manifestation of the values of the field and shape the behaviors and attitudes of students, instructors, and engineering as a whole. The curricula's focus reveals the priorities of the field as a whole, so by retooling the foci of curricula, we may be able to retool the culture and climate of engineering education.

Messaging and Culture in Curricula

The National Academy of Engineering argues that if issues of sustainability are addressed only by industrialized countries, then those countries will "remain islands in a sea of environmentally bereft developing countries" (p.21),[9] and I contend that this is similar to issues of diversity and inclusion. If only people from underrepresented groups focus on the challenges and benefits of D/I or if we allow students to self-select into courses that explicitly engage with D/I, then we will continue to have islands of understanding among those who have the resources or personal connections without major impact on the greater profession or on attrition rates.

When issues of D/I are positioned as concerns only for the underrepresented, dominant messages or stories of engineering as white and male are left intact. Brewer, Sochacka, and Walther argue that conventional institutional discourse creates and reproduces stories (often unintentionally) that reassert the importance and privilege dominant communities and their concerns. These stories "shape educational realities by being continuously told, re-told, and enacted" (p. 3)[10] through materials disseminated by professional engineering organizations as well as resources, prompts, assignments, and assessments in engineering education classrooms. By contextualizing engineering education within diverse sociocultural realities, we can alter the stories that narrowly define the parameters and expectations of appropriate topics engineering and who is or can be an engineer.[10] Expanding the parameters may mean that a wider range of people may envision themselves as engineers.

For example, Blaser, Steele, and Burgstahler contend that curricula centering on the social and cultural impacts of engineering-in-practice "may support the recruitment, retention, and long term success of women, people with disabilities, and other underrepresented groups in engineering."[11] I take this a step further and argue that contextualizing engineering education projects and curricula can appeal to and help the success of not only underrepresented groups but also those from majority populations through the focus on real-world application of classroom activities and lessons, and by providing individuals with the tools needed to engage in a multicultural, global workforce.

Particular basics of engineering have not and will not change much over time, but the National Academy of Engineering argues that in an increasingly diverse society "consideration of social issues is central to engineering" (p. 44).[9] Further, there is an ongoing and necessary evolution within engineering due to globalization and "a growing need for interdisciplinary and system based approaches, demands for customerization, and increasingly diverse talent pool" (p. 21).[9] One of the ways that engineering education can support this evolution of engineering is by rethinking the framework we provide during fundamentals courses and other general education coursework (GEC) or major courses offered by engineering education departments.

Focusing on fundamentals, major, and GEC courses serve two purposes:

1. Fundamentals courses establish an engineering discourse community and community values. When D/I is included in the curricula, it demonstrates that D/I is valued and fundamental to engineering and provides future engineers with the tools necessary to engage with and exploit[12] the benefits of diversity.

2. In other engineering major courses or GECs offered by engineering education departments, D/I demonstrates to both engineering majors and non-majors the importance and relevancy of D/I for practicing engineers, potentially shifting broader assumptions about who is an engineer and what engineering does.

All engineering students, regardless of specialization, must take fundamentals courses, and as such, these courses establish the discourse community and values for students' education and understanding of what engineering writ large is and does. GECs offered by academic departments generally function in a similar way: these courses establish the discourse and values of that particular field for a broad audience, so GECs offered by engineering units could go far to impact the overall assumptions about engineering as a discipline. Fundamentals and GECs using D/I frameworks will not only provide future engineers with the sociocultural knowledge needed to be successful in an increasingly diverse and global workplace but also help battle long standing perceptions of engineering disciplines as concerned primarily or only with the experiences and need of the majority. Additionally, a focus on D/I may alter the climate and culture, making engineering as a whole more welcoming and viable for underrepresented groups.

If D/I are included in the curricula fundamentals and GECs, the message or story provided to all students is that engineering and engineering education are relevant for and consider the needs of all communities. This move can help "the engineering profession…to develop solutions that are acceptable to an increasingly diverse population and…draw more students from sectors that traditionally have not been well represented in the engineering workforce" (p.45).[9]

So what might this shift toward D/I look like in an engineering course? The following section examines an engineering GEC, Engineering Technical Communications, and the ways in which D/I are central to the course. The section also explores how small changes to a fundamentals course could help provide future engineers with the tools they need to be successful in diverse workplaces.

A Closer Look: D/I-in-action

How might engineering education courses incorporate D/I in a rhetorically useful and effective way? I briefly discuss possible approaches, focusing on a GEC technical communication and writing course and fundamentals of engineering courses offered by a Department of Engineering Education.

Engineering Technical Communications (ETC) and D/I

Engineering Technical Communications (ETC)—listed as American Attitudes Toward Technology—is an unusual engineering education course that meets a variety of requirements and needs. It is a double GEC, providing credit for both second-level writing and social diversity in the U.S. coursework. It is also a rhetoric-based composition course centered on rhetorical and multimodal approaches to visual, aural, and textual technical communications. ETC is the only course offered in the Department of Engineering Education that meets the university's social diversity in the U.S. GEC. The course is taught by professionals and academics who have had their training largely outside of engineering disciplines, but who have relevant experience and have demonstrated commitment to not only STEM but also a contextualized, rigorous curriculum that focuses on the diverse communicative challenges and expectations students may face in the engineering workplace.

ETC is not a required course for engineering majors and is open to all students enrolled at the university(students may take second-level writing from over 30 different departments), but approximately 70% of the students enrolled in ETC during a given school year are engineering majors. Though the department offers some Humanitarian Engineering courses and events, in many cases ETC is the only course engineering students enroll in that explicitly discusses and engages in library and professional research about D/I in STEM.

Due to its status as a social diversity GEC, D/I are central to the course as a whole. Most projects have some kind of social diversity aspect or component. Students are provided with frameworks for understanding, interacting, and engaging with diversity and issues relevant to D/I. For example, resources about implicit and similarity biases are assigned and discussed in small and large groups. The purpose is to provide students with language and mental frameworks for understanding and interrogating D/I in STEM, including historical data as well past and current disparities, causes, and potential solutions. Students are taught how to perform library and industry research, and we explore research and resources from organizations such as the Society of Women Engineers (SWE), the U.S. Census Bureau, the Bureau of Labor Statistics, the National Science Foundation, National Academy of Engineering, and so on. The goal is to expose students to a wide range of data, research, and scholarship and a range of rhetorical approaches and contexts for exploring D/I and STEM.

Centering the course on rhetoric allows us the room to examine audience, purpose, and context in-depth, and when combined with the discussion on D/I, students are provided with a relatively neutral way to approach diverse communicative contexts and communities. The assignments naturally lend themselves to discussions of D/I. For example, students spend a lot of time exploring engineering workplaces, including a Job Unit and a Diversity Hiring Recommendation Memo Unit. In both instances, students are provided with research, scholarship, and historical data to understand hiring trends, disparities, and options for improving their own materials and evaluating the materials and experiences of other. The Diversity Hiring Recommendation Memo tends to be the assignment where majority students begin to understand the specific concerns and issues underrepresented individuals may face when entering the workforce and throughout employment. Students act as employees of a relatively small tech start-up, and their boss requests a researched recommendation memo about how to improve the overall diversity and hiring practices at the company. Students are provided with a variety of articles, both academic and popular; then they must research and identify additional relevant sources to develop specific actions that the company can take to increase diversity and improve the hiring processes overall. In written post-assignment reflections, many students indicated that prior to this assignment and reading the research, they really did not understand, care, or even consider why diversity might matter or the barriers that some underrepresented groups may face in the workplace, despite high qualifications.

Ultimately, ETC provides students with mental and rhetorical frameworks for thinking, talking, researching, and writing about issues of D/I as they relate to STEM education, workplaces, and innovation. The goal is to provide students with explicit frameworks, strategies, and resources for engaging with diverse communities and workplaces. However, ETC is not a traditional engineering course. This means that ETC has different expectations and more room to play with curricula and content than fundamentals courses. Despite this, I contend that it is possible for fundamentals courses to incorporate D/I components while maintaining rigorous technical standards.

Fundamentals and D/I

If a GEC such as ETC is the only engineering course students take that explicitly and repeatedly discuss issues of D/I, then it may be relatively easy for students to see D/I as a niche concern rather than fundamental to effective and responsive engineering. This is why I argue for the incorporation of D/I in Fundamentals of Engineering (FE) courses.

FE courses' objectives at my university state that students will: "Gain a solid understanding of foundations of Engineering…Develop the skills and values that support good teamwork…Develop the skills and behaviors required of a professional engineer." D/I is relevant to these course objectives for a few reasons. First, informed, critical, and thoughtful behaviors and actions are necessary for effective and innovative engineering projects. Second, engineering is a global discipline, consisting of not only multidisciplinary but also multicultural teams, which require nuanced and educated approaches to diversity and difference. In other words, understanding and developing strategies for engaging with D/I are fundamental to becoming an effective and responsive engineer.

Of course, FE courses are packed with ABET-required, technical components, which might make it hard to see how D/I could possibly be incorporated into an already full schedule. I argue that some micro-lessons at the beginning of the term could be used to establish a vocabulary, framework, and shared set of resources about D/I in STEM and engineering in particular. This might include definition and discussion of implicit biases; research or studies about innovation and diversity as well as humanitarian engineering; and industry and governmental data on STEM participation. Then, when students are provided scenarios for projects, such as labs on wind turbines, solar energy, trains, or alternative energy, they would be framed within a specific diversity social reality. The context provided to students could reflect the social and cultural needs and considerations that factor into engineering projects in real life.

For example, students might be required to use Matlab and SolidWorks to program and design a train or alternative energy vehicle to complete certain tasks. It can be relatively easy to use fictional settings and tasks for these types of assignments. Students may be excited or more interested in an assignment that is couched in the world of one of their favorite movies. However, instead of grounding the assignment in Jurassic Park or the Star Wars, instructors should center the assignments on diverse lived social contexts. Instead of helping imaginary visitors to Jurassic Park get around a dinosaur park or helping the Rebel Alliance prepare for battle with the Galactic Empire, the assignment could focus on helping low income communities more effectively access job or educational opportunities, helping rural students connect with urban resources, and so on. As part of their documentation, students would provide a brief analysis of the social reality (audience, purpose, context) as well as a reflection on how and why their design best meets the needs of the community. Grounding the assignments in diverse real world contexts in conjunction with D/I discussions and reflections will demonstrate to students that engineers work within diverse communities and constraints and engineers must consider the needs of a wide range of communities in order to be effective. This demonstrates that D/I are fundamental to engineering practice.

The overall goal of these explicit discussions and applications of D/I is to demonstrate that diversity is reality and engineers must be ready to engage with D/I. By making diverse realities a part of the intellectual work of engineering education, we demonstrate that engaging with D/I is not an afterthought or a niche concern for Others but a central aspect of the "skills and behaviors of required of a professional engineer."

Conclusion

Engineering Education (EE) is the gateway to engineering practice, and if our purpose is to prepare students for engineering workplaces and contexts, then we must make D/I a core part of our curricula. In a global society, diversity is reality, but inclusion is a choice. Similarly, the engineering leaky pipeline is a reality, but we have the power to change that reality—if we choose to. Recruitment and outreach stock the pipeline, but without a focus on *inclusion* (in our materials, curricula, behaviors and practices), we will continue to see underrepresented, talented, and qualified engineers leave the major and profession. Because EE touches almost all future engineers, we are in a unique position to alter institutional and disciplinary cultures and climates, placing upward pressure on workplaces' climates and cultures to make similar changes.

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