From "Leaky Pipelines" to "Diversity of Thought": What Does "Diversity" Mean in Engineering Education?

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Abstract

The recruitment and retention of women and minorities is a task of paramount importance in engineering programs, and higher education in general. However, despite continued efforts to diversify the student body, women and minorities have remained underrepresented in engineering departments. The rationale for increasing diversity in engineering education can vary, from industry arguments about "filling pipelines" for the labor force, to social justice arguments that everyone should have an equal opportunity for success, to cognitive diversity arguments that problems are solved more efficiently with diverse viewpoints. Furthermore, there is significant variation across institutions regarding who is prioritized under the "diversity" umbrella – some highlight women in general, others African American, Hispanic and Latinx men and women, others target students of low socioeconomic status (SES). Finally, initiatives to address diversity also vary widely, from scholarship programs, to extracurricular activities, to integration of the needs and interests of excluded groups into coursework. This research paper draws upon data collected as part of a multi-institutional research study entitled "The Distributed System of Governance in Engineering Education." In it, we analyze diversity discourses among faculty and administrators in engineering programs across the Unites States, and the initiatives deployed in the name of diversity. We use methods of discourse analysis to study how the term "diversity" is leveraged in different contexts to enact certain methods of recruitment and retention of particular populations.

Introduction

Diversity initiatives have been a priority in university settings for decades, but have largely not delivered on their promises. The percentage of bachelor's degrees awarded to Hispanic, Black and Native American students is in the single digits [1], and the proportion of women in engineering over the past two decades has stalled at just below 20% [2]. Although there have been some recent attempts to attend to the intersections of gender and race, women of color have largely been "lost in the numbers" [3]. Broken out by race, White women earn 11% of engineering degrees, Asian women 2.5%, Hispanic women 2%, Black women 1% and Native American women less than 1% [1]. The study of persistent inequalities in higher education, particularly in STEM disciplines, has become a great interdisciplinary effort, found in education departments as well as sociology, anthropology, gender and critical race studies, history, and organizational studies. Many of these studies utilize student perspectives to illuminate the unique challenges for historically excluded populations [4]–[7]. Fewer studies examine faculty and administrators' perspectives and engagement with diversity initiatives [8]–[10]. These studies emphasize the importance of faculty-student relationships for underrepresented groups, as these relationships can be a critical component for their career success. Administrative support is also crucial for implementing diversity policies in university settings. This study utilizes data from a collaborative nation-wide study on engineering education reform to examine diversity rhetoric of faculty and administrators in a range of university settings. In particular, we ask which student

groups faculty and administrators perceive as being included under the diversity umbrella, their rationales for why diversity is important.

Since we are interested in diversity rhetoric in this paper, it is important to acknowledge that the terms "minority" and "underrepresented minority" are themselves designations that categorize and spatialize, label and organize. Audra Simpson calls this "the analytics of 'minoritization'" [11, p. 18]. Although we typically use the term "underrepresented minorities" to refer to Black, Hispanic and Native American students in engineering, we acknowledge that this is an etic construction that has been useful from the perspective of the state and other social institutions. It is not necessarily consistent with how students perceive their own experiences and neglects the wide variety within such designations. Nonetheless, these broad racial categories have a profound effect on the trajectory of students' lives. Walden et al. [12] have suggested the replacement of the term "underrepresented minorities" with "excluded identities" to foreground the role of engineering institutions as the agents that exclude, to discontinue the practice of viewing students as bodies to be counted, and to remind ourselves that students exist at the nexus of multiple intersecting identities, some privileged and some not. We have tried to use this new terminology as much as possible in this paper.

Given the wide-ranging meanings of the term "diversity", it is instructive to return to its historical context. Although the U.S. has long prided itself on being a cultural melting pot, the term "diversity" is relatively new in American history, emerging out of the Civil Rights Movement in the 1960s [13]. In science and engineering, diversity projects were influenced from three directions. First, the new Affirmative Action policy required that all government-funded programs – including many universities – actively pursue and promote members of disadvantaged groups, which included racial minorities and later, women [14, p. 26]. Second, corporations in science and technology sectors, preparing for a dramatic growth in scientific jobs, sought to recruit from a wider range of potential employees [14, p. 69]. And third, activist groups who supported equality in all sectors of the workforce embraced the promotion of women and minorities in science and engineering [14, p. 70]. Collaborations between universities, advocacy groups, and corporations – with funding from new programs within the National Science Foundation – resulted in a host of outreach efforts to women and racial minorities[14, p. 76]. In the 1980s, realizing that equitable education, recruitment and equal pay were not enough to retain women and minorities in scientific careers, universities and corporations began implementing "diversity management" programs to improve retention of employees [14, p. 142]. Diversity programs have also been adopted in order to help institutions avoid severe legal penalties in discrimination lawsuits [15], [16].

Today, diversity programs are quite popular, particularly in educational environments [13]. The diversity umbrella has expanded from women and racial minorities to include protection against discrimination for religious differences, LGBTQ individuals and those with disabilities. The term has become ubiquitous in everyday speech and can be used as a stand in to indicate any type of variation in groups. Indeed, some authors have argued that diversity rhetoric has become too diluted. "Diversity rhetoric…tends to equate differences based on geography and taste in sports or dress style with difference based on race and sex" [17, p. 1626]. In the recent "Google Manifesto", the author invoked diversity – in this case, diversity of political views - to argue *against* racial and gender diversity initiatives at work [18]. These equivalences ignore the

systemic racist and sexist structures that reinforce inequalities in the education system. Furthermore, as we highlighted in the statistics at the outset of this paper, diversity initiatives in engineering education have thus far over-promised and under-performed, and racial minorities do not equally benefit from diversity programs [3], [19]. This has led to calls to scrutinize more carefully what is meant by "diversity" in STEM fields and clearly distinguish who are the intended beneficiaries of such programs [3].

The rationale behind implementing diversity programs has also faced critique in recent decades. A key metaphor for understanding the goals of diversity programs is the "leaky pipeline" model. This metaphor was originally used to visualize women's progress from PhD to tenured faculty and senior leadership in academia [20], but has been repurposed as a metaphor for the retention of all excluded identities in science and engineering. In this model, students are recruited to STEM fields during their undergraduate degree and then slowly leak out at various stages in their careers. The "successful" student emerges at the end of the pipeline as a career academic or industry professional in a scientific field. The leaky pipeline has been criticized by some for its passive portrayal of students who are affected only by market forces [21]. Others take issue with the fact that this model does not acknowledge that some demographic groups leave at greater rates than others. Johnson et al. write, "…there is nothing special about the water that stays in the pipe and that which leaks" [7, p. 342]. Still others note that careers are more complex than the "leaking only" action of the pipeline – some successful scientists may leave and then return, or may find fulfillment in other fields [22]. As an alternative, authors have proposed other models, such as Etzkowitz's [23] "vanish box" in which underrepresented students (women, in particular) tend to vanish from scientific careers, but reappear in careers that combine science with business or communication skills. Perna [24] also suggests a "multiple pathways" model, which has been picked up by advocates for minority engineers [19]. Perna's model allows for alternate routes within higher education, in particular acknowledging the role of community colleges and minority-serving institutions.

Some authors have taken issue with the "business case" for diversity that is currently widely circulated in STEM careers. The economic justification for the importance of diversity relies on arguments that diversity increases productivity, creativity, and teamwork [25]. Sometimes referred to as "cognitive diversity" or "diversity of thought", it makes the case that diverse groups come up with better ideas and solutions than homogenous groups. While this has become a popular argument, its premise has been challenged by skeptical social scientists [13], and employees remain unconvinced [26]. Sharp et al. [27] argue that regardless of whether diversity does indeed deliver a market advantage, economic discourses tend to elide the power dynamics that reproduce inequalities in engineering workplaces. Simply adding women and minorities to teams does not change the social dynamics which keep them on the periphery (for an excellent example of the persistence of inequalities on engineering design teams, see [28]).

For this reason, many authors have insisted on a strong commitment to equality, which advocates for students with historically excluded identities without the need to insist on their value to the scientific workforce [7], [29]. Equality, or social justice, arguments in support of diversity in STEM begin with the premise that minorities and women are unequally represented in science, and that this contributes to broader racial and gender inequalities in pay, prestige and power. "[S]cience degrees and occupations are associated with greater prestige and rewards than

any other field of study. In a technologically advanced society, the status and power of those in science makes them the new elite" [29, p. 113]. Therefore, it is imperative that science and engineering disciplines are equally accessible to all, regardless of race or gender. The political nature of social justice arguments makes them uncommon in a discipline that prefers to maintain its objectivity [30]. However, the "equality case" for diversity is the only argument that takes into account pre-existing power structures that reproduce racial and gender inequalities.

These various diversity rationales contain important insights into how institutions and individuals perceive the problem of diversity in engineering. While economic discourses have been shown to be popular in business environments [27], it is not clear whether they are similarly popular in education. Therefore, it is one of the goals of this paper to examine the rationales faculty and administrators use to promote diversity in university settings. We concur with Pawley's [33] recent argument that diversity must be an expected outcome for engineering education and argue that for this to occur, all faculty and administrators must be engaged in this effort.

Methods

The data discussed in this paper was collected as part of a broader research project on engineering education reform, sponsored by the National Science Foundation (NSF), entitled "The Distributed System of Governance in Engineering Education" (NSF, SES-1656125). This project explores the mechanisms of change in engineering education, primarily through semi-structured interviews with various actors involved in engineering education, including university administrators and faculty, professional societies (e.g., ASEE, NAE), assessment regimes (e.g., ABET) and institutions that fund research (e.g., the NSF). It asks what kinds of initiatives are taking place at universities across the United States, what gave way to such initiatives, and what are the perceived obstacles and barriers that prevent meaningful reform. Among these initiatives, diversity is a frequently-cited concern among university faculty and administrators, and a variety of initiatives are taking place at these institutions to improve access and retention for excluded groups.

This paper considers interviews conducted at six (6) universities in the data set. Among these universities, three (3) are minority-serving institutions (MSIs), two (2) are prestigious research institutions and one (1) is a land grant institution. These institutions were selected based on availability of full transcripts; while there are several other participating universities in the study, many are still undergoing transcription and data processing at this time. We hope to include more institutions in this analysis at a later date. We have decided to maintain the anonymity of all participants and institutions discussed in this paper. A total of forty-seven (47) interviews were analyzed: nine (9) at Institution A, eleven (11) at Institution B, four (4) at Institution C, eight (8) at Institution D, seven (7) at Institution E, and eight (8) at Institution F. A wide range of administrators and faculty were interviewed at each institution, ranging from provosts to advising staff, providing a broad perspective of education at various professional levels.

This data set has certain limitations. First, due to the small sample size, these results should not be taken as representative of all universities in the United States. Future studies

should explore the trends identified in this paper to determine whether they hold at larger scale. Second, the selection of interviewees was left up to the universities, and they typically selected interviewees who were deeply involved with undergraduate teaching. These participants were often leaders of particular innovations in engineering education that the universities felt were most important to them. As a result, research faculty were under-sampled, as were faculty associated with graduate education or "old-fashioned" teaching methods and styles. More importantly, we did not ask direct questions about diversity. Diversity topics were brought up by faculty and administrators as key initiatives they are seeking to address. This biases our data set toward faculty and administrators who strongly feel that diversity is an important issue, which may skew the results toward a population that is more knowledgeable about diversity than we might expect. In addition, many faculty who did not bring up diversity on their own may also feel strongly about diversity, and simply didn't think about it at the time of the interview. However, our position as investigators studying educational reform more broadly does provide a small advantage - since we did not position ourselves as the "diversity police," interviewees may have felt they could speak more freely about the inequalities they have encountered in engineering education.

We ask two general questions about this data set: (1) Given the wide range of excluded groups categorized under the "diversity" umbrella, who do faculty and administrators consider to be the target of diversity programs? (2) What rationale do they use to support their participation in such programs?

We utilized structured coding methods [34], [35] to tag sections of interviews related to each question; these codes were further subdivided into several sub-categories. Comments that did not fit easily into a pre-defined code were placed into an "Other" category. Following the coding, a series of analytical memos were written to process and interpret the coded data [36], [37]. One of the benefits of a large research team is the ability to easily conduct peer checks. The results were discussed amongst a small group of four graduate and undergraduate assistants before being checked again by the rest of the project team. Such reviews are recommended to ensure "trustworthiness" of qualitative data [38], [39].

Diversity Type

Despite previous research in industry settings that found that diversity rhetoric has become diluted, in these six academic settings, diversity initiatives squarely target racial and gender inequalities. All institutions in the sample mentioned a desire to improve the retention of Hispanic – and to a lesser extent, African American and Asian – engineers. Women were also key targets of diversity reform, and at some institutions women were mentioned more frequently than racial minorities. Native American, LGBTQ and disability equality were both conspicuously absent in these interviews; only one mention of each was made.

Students of low socioeconomic status (Low SES) were the most frequently mentioned group, and this language overlaps considerably with comments referring to Hispanic and African American students. Thus, racial minorities become equated with students who are "underprepared", "first generation" and/or "commuter students" who must work and go to school simultaneously. Of course, many of these students are indeed low income and do require extra

preparation for college. The danger here is the unspoken assumptions that position Hispanic and African American students as disadvantaged.

In some cases, Low SES language is used to provoke compassion or empathy, to more fully describe the students in question. Such comments invoke the struggle that many minority students experience with managing expectations of family, school, and often a part-time or full-time job.

In other cases, references to socioeconomic status seem to be used to avoid the political language of race. This rhetoric becomes a "shadow language" that indicates race, but does not name it explicitly. It includes terms such as "accessibility", "affordability", "underprepared", "low knowledge base", "transfer students", "commuter students", and "first generation". This shadow language does two things: (1) it allows universities avoid singling out any particular racial group in their programs - which they are prohibited from doing by law [13] - by targeting Low SES groups more broadly; and (2) it allows faculty to avoid discussing race through the use of apolitical references to social class.

In these instances, the challenge is to be careful about the language we choose to describe students of color, and avoid the assumption that all students of color are underprepared or disadvantaged. The risk is that this language will "stick", following racial minorities long after remedial and financial measures have been addressed, and setting them up for perpetual questioning of their expertise as they continue their careers. Furthermore, using the broad language of Low SES whitewashes the ways that low SES racial minorities' experiences may be significantly different than white Low SES students. If we treat all Low SES students as if they are white Low SES students, it should be no surprise to find that white students end up benefitting more than nonwhite students from these programs.

In addition, not all schools discussed diversity at the same level of depth. Indeed, the number of faculty who mentioned diversity as a key reform initiative was rather low in some schools. At the MSIs, nearly every interviewee seemed to be fully engaged in diversity initiatives. However, at two universities, half of the interviewees did not bring up diversity at all. As we mentioned earlier, given that our interviews were primarily about education reform, neglecting to mention diversity does not necessarily mean that it was not important to those interviewees. However, it does indicate that other reform initiatives (usually research-related) held higher priority.

We also find evidence for the dilution of diversity rhetoric in academia, (for example, referring to diversity of dress styles or sports preferences, as observed in industry environments by Williams et al. [40] and Edelman et al. [17],) in faculty and administrators' comments. These terms include "geographic diversity", "hands on" diversity, diversity of teaching skills, and diversity of institution types. These terms depart from the original intent of diversity rhetoric, in that these types of diversity do not correct imbalances of power between structurally disadvantaged groups. In other words, improving geographic diversity probably does little to improve gender or racial inequality.

Some faculty raise concerns about their encounters with diluted diversity rhetoric.

> "[I]n design teams, they used to have multidisciplinary teams, but now they say that design teams need to have a certain level of diversity, but they let you define what is diversity. It doesn't have to be ethnic diversity, it can be a diversity of grades…I can define this any way I want, so with a little bit of thought I can get any outcome I want. Does this really make sense?"

These comments indicate that some are frustrated by the lack of specificity of diversity rhetoric in academia. If diversity can mean whatever you want it to, what is the point of enforcing it? We discuss some of the implications of these frustrations in the discussion section of this paper.

Diversity Rationale

Since we did not directly ask why faculty and administrators thought diversity was important, this factor was more difficult to evaluate. We were reliant upon the interviewees to explain their own views unprompted. From these comments, we find that the "leaky pipeline" metaphor remains stalwartly relevant, and some faculty refer to it directly. In fact, many diversity programs themselves imply a "pipeline" mentality, with stages lined up back to back, seeking to plug the leaks and improve retention at various checkpoints during a students' education.

Others contain indirect references to the pipeline, emphasizing the desire to recruit minority students for the express purpose of transporting them to industry. For one administrator at a Hispanic Serving Institution, the mandate of an HSI is perceived to be tied to the recruitment and retention of Hispanic engineering students, with the direct goal of depositing those students into the workforce. This interviewee indicates that Hispanic students are actually easier to retain after their entry into the workforce as well, and as such, are a solid investment for industry partners.

However, there is some evidence that the interpretation of this model is changing to include more of the recommendations contained in the "multiple pathways" recommendations [24], which highlights the pathways and barriers to minority students' access to higher education. In particular, faculty and administrators appear to have an increased awareness of the importance of community colleges and a greater willingness to accommodate transfer students. Two institutions in our sample actively cultivate transfer students at partner community colleges and minority-serving institutions to provide more opportunities for students with excluded identities to access an elite education. This is a clear indication that the "multiple pathways" model is beginning to catch on in academic institutions.

The other rationale that came through strongly was a quasi-equality rationale. Particularly at the MSIs, many faculty stressed the transformative power of an engineering education to change the lives of their students, their families, and their communities. Although this differs slightly from purer forms of the equality rationale, in which diversity is important in order to correct historical inequalities of excluded groups, these statements indicate that faculty are committed to helping these individual students and their families achieve social mobility. It is unclear whether faculty are familiar with the structural inequalities that underlie diversity

programs, and no educator ever used the word "racism" in their interviews. However, the commitment to social mobility as an outcome of diversity efforts indicates that equality rationales may be more broadly popular in academic settings than has been noted in industry environments.

Discussion

This paper has offered a preliminary analysis of diversity rhetoric in engineering education, with particular attention to who is the target of diversity programs and why diversity is believed to be important. We are most concerned with the use of apolitical low socioeconomic status rhetoric as stand-ins for serious conversations about racial inequalities. If we limit our understanding about the needs of Hispanic and African American students to simply broad financial and remedial needs, we are bound to miss some of the unique challenges faced by students of different racial backgrounds. For example, many faculty members mentioned students' commitment to family as a key concern for Hispanic students. By focusing only on the economic factors, we risk missing the cultural factors that nuance economic conditions. Furthermore, the consistent linkage of racial minorities with under-preparedness may stick, leading to perceptions that they are unprepared long after they have completed their education. This has long-term repercussions for their careers.

We highlighted a few examples of the dilution of diversity rhetoric in academia, including geographic diversity and diversity of hands-on skills. The professors who complained that "with a little bit of thought, I can make [diversity] mean whatever I want" are expressing confusion and frustration with the flexibility of this rhetoric. This flexibility causes those who might be inclined to participate in diversity efforts to disengage, reasoning that this word doesn't really *mean* anything at all. If diversity is intended to reduce inequalities, as we believe is consistent with its historical context, we should be more careful to limit its use to groups who experience social disadvantages. Consistent with social justice ideologies, this interpretation of diversity acknowledges the power structures that create these inequalities, and seeks to correct them.

We have also explored why faculty and administrators believe diversity should be pursued. Although the "leaky pipeline" model remains relevant in academia, we are inspired to see movement toward a "multiple pathways" approach, particularly in faculty and administrators' perceptions of transfer students and community colleges. Although it is possible these attitudes are not yet widespread, the embrace of transfer programs enables students with excluded identities more opportunities to gain access to an accredited engineering program. Furthermore, the equality rationale appears to resonate more strongly among our academic interviewees than has been found in industry, indicating that social mobility for excluded groups is a key factor in their participation in diversity initiatives – even if they would not themselves characterize it as social justice. Although no one mentions racism specifically, this is an important finding, since it indicates that at least some faculty in this sample are attentive to the power structures that underlie inequalities in education.

Finally, we call attention to the fact that not all faculty are engaged in diversity efforts, and our sample indicates that many faculty prioritize other types of reform. Perhaps this is why

the number of women and minorities in engineering is abysmally low and has not made much progress. In order for improvements to be made, all faculty must feel empowered to help improve conditions for excluded groups. These efforts do not have to be as time-intensive as starting a new diversity initiative. This could be as simple as hiring students with excluded identities for our research projects, or making an effort to read literature about the needs of students with different racial backgrounds. A little extra effort can go a long way. When it comes to making real changes in the status quo, it must be all hands on deck or we are setting ourselves up for more disappointing results in the future.

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