Diversity and Inclusion within the Context of the Professional Formation of Engineers: Impact of the COVID-19 Pandemic and Increased Attention on Racial Disparities

Memoria Matters, Purdue University at West Lafayette (COE)

Memoria Matters is a PhD student in the School of Engineering Education at Purdue University. She is also pursuing a Master's degree at the School of Electrical and Computer Engineering for computer engineering, in which she obtained her BSE from the University of Pennsylvania. Her research interest is in increasing the diversity of engineering by improving the inclusivity of engineering higher education through teaching methods, policies, and culture change.

Dr. Andrew O. Brightman, Purdue University at West Lafayette (COE)

Andrew O. Brightman serves as Assistant Head for Academic Affairs and Associate Professor of Engineering Practice in the Weldon School of Biomedical Engineering. His research background is in cellular biochemistry, tissue engineering, and engineering ethics. He is committed to developing effective pedagogies for ethical reasoning and engineering design and for increasing the diversity and inclusion of engineering education.

Prof. Patrice Marie Buzzanell, Purdue University at West Lafayette (COE)

Patrice M. Buzzanell is Professor and Chair of the Department of Communication at the University of South Florida and Endowed Visiting Professor for the School of Media and Design at Shanghai Jiaotong University. Fellow and Past President of the International Communication Association (ICA), she served as President of the Council of Communication Associations and the Organization for the Study of Communication, Language and Gender. She is a Distinguished Scholar of the National Communication Association. Her research focuses on career, work-life policy, resilience, gender, and engineering design. She received ICA's Mentorship Award and the Provost Outstanding Mentor Award at Purdue, where she was University Distinguished Professor and Endowed Chair and Director of the Susan Bulkeley Butler Center for Leadership Excellence. She has worked with Purdue-ADVANCE initiatives for institutional change, four EPICS teams including Transforming Lives Building Global Communities (TLBGC) in Ghana, and individual engineering ethical development and team ethical climate scales as well as everyday negotiations of ethics in design and professional formation of engineers through NSF funding. [Email: pmbuzzanell@usf.edu; buzzanel@purdue.edu]

Dr. Carla B. Zoltowski, Purdue University at West Lafayette (COE)

Carla B. Zoltowski is an assistant professor of engineering practice in the Schools of Electrical and Computer Engineering and (by courtesy) Engineering Education, and Director of the Vertically Integrated Projects (VIP) Program within the College of Engineering at Purdue. Prior to her appointment in ECE, Dr. Zoltowski was Co-Director of the EPICS Program. She holds a B.S.E.E., M.S.E.E., and Ph.D. in Engineering Education, all from Purdue. Her research interests include the professional formation of engineers, diversity, inclusion, and equity in engineering, human-centered design, engineering ethics, and leadership.

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Introduction

In the U.S., the COVID-19 pandemic has caused significant distress for many families and individuals, but perhaps predominantly among marginalized communities of color [1]. Beyond the medical toll, the negative impacts on social and economic conditions have been devastating for many ethnic and racial minorities. Many of these are young people and some are students in engineering [2]. The challenges of navigating higher education and professional formation in engineering are formidable enough for those lacking the expected social capital for academia [3]. However, the challenges are intensified as the pandemic conditions threaten family, livelihood, and economic and social well-being. From our vantage point of several years of research on diversity and inclusion issues in engineering professional formation we were concerned that the enormous challenges already in play for minority populations in academia would be exacerbated by the negative impact of the pandemic on the entire educational system [4], [5]. This concern was reinforced by the rising attention to racial disparity and the increasing social unrest in light of deadly attacks on black and brown men and women and their influence on the social systems of higher education and engineering specifically [6]. We sought to understand the potential additive effects of these twin stressors, viral pandemic and social unrest, on the ability of engineering programs to continue efforts toward increasing diversity, equity, and inclusion in professional formation.

In our NSF RFE sponsored research project, we have been investigating the intersection of three goals in engineering education: professional formation of students, an integrated sociotechnical perception of engineering, and increased diversity and inclusion. In the initial phases of research, we approached the investigation into understanding and ideating about social change using design thinking. We engaged with faculty, staff, and students in a collaborative design process as part of a comparative study of two engineering departments – the School of Electrical and Computer Engineering (ECE) and Weldon School of Biomedical Engineering (BME) – at Purdue University, a large, research-intensive university. Our project has been organized around the three phases of the design process (inspiration, ideation, and implementation), and embedded within the design process is a longitudinal, multiphase, mixed-methods study. The research was guided by the following questions:

RQ1. How might we make engineering more inclusive?
RQ2. How might we better prepare engineering graduates for practice?
RQ3. How might we use design thinking to address complex issues in engineering education?

In this final year and phase (Implementation) of the project, we have been both challenged and enabled by events and shifting conversations around the viral pandemic of disease and the widespread activism around racial injustice. In this paper we will discuss how the current events have affected our research and implementation in surprising ways, guided by the following additional research question:

RQ4. How have the pandemic and attention to racial inequalities impacted RQ1 – RQ3?

In this paper, we provide an overview of the larger project's previous analyses of the surveys and interview data from faculty, staff, administrators, students, and alumni in both ECE and BME which we have conducted. These analyses will provide insight on the indirect and/or longer-term impact on the school's cultures and on aspects that are more embedded in the schools and disciplines, as well as those that are more amenable to change. In addition, we describe how design processes and mindsets have and can be used to address complex issues in engineering education, and how this approach facilitated the working groups/committees that emerged in both BME and ECE as part of this project. We also describe the data we are collecting in the final year of the project to understand the impacts of this project, as well as the impact of the COVID-19 pandemic and the attention to racial disparities on our research questions.

Project Overview

Previously, as part of the Inspiration Phase, we collected and analyzed survey, interview, and observation data from a broad set of stakeholders which included faculty, staff, and administrators and students (undergraduate and graduate) in both ECE and BME departments [7]. During the Ideation phase, we facilitated co-design sessions with faculty, staff, and students in each of the two departments to investigate underlying systemic issues and barriers that would inform and shape the development of prototype social change initiatives related to diversity and inclusion and professional formation [8], [9]. During the Implementation phase, we have been working with BME and ECE stakeholders to further define and develop these prototypes, through ad-hoc working groups resulting from the co-design sessions.

Our research team has conducted several analyses that, together, are providing insight to the disciplinary, department, and university cultures that underlie the interconnected issues related to professional formation, integrated socio-technical understands of engineering, and diversity and inclusion [3], [10], [11], [13]. Furthermore, the analyses are revealing how those cultures can shape the ways in which design thinking can be used as an effective strategy for addressing these wicked problems of social dynamics and organizational change. In the following sections, we briefly describe the context of these analyses and summarize the findings.

Finding 1 – The disciplinary culture of BME promotes independence and individuality as norms for student success which allows faculty to prioritize research. Through interviews with 18 current or former BME students and 15 faculty and staff members, we examined norms of teaching and learning in the BME disciplinary culture, discovering that students, faculty, and staff perceived the BME culture as reinforcing highly independent strategies for learning and professional development. Although faculty framed these as productive and necessary skills for students, students perceived that faculty prioritized research and that they were 'on their own' in: (a) developing a specialty in a BME subfield to be marketable upon graduation, (b) learning course content by teaching themselves, and (c) finding and pursuing professional development opportunities. As a result, students drew on resources outside of the program such as family and peer social networks, high school training in STEM subjects, and other forms of social and cultural capital. As under-represented minority (URM) students and first-generation college (FGC) students are less likely to possess these forms of capital, this finding suggests that BME

cultures may raise barriers to URM and FGC students. A more in-depth discussion of these findings can be found in [3] and [11].

Finding 2 – The organizational cultures influenced participants' perceptions of change possibilities related to diversity and inclusion, and their role in change. Analysis of the post-design session interviews revealed the influence that the disciplinary/organizational cultures of both ECE and BME had on (1) the effectiveness of design thinking toward culture change, and (2) where change occurred (e.g., individual versus systemic levels). Reflecting a more limited design culture within the school, the stakeholders in the ECE design sessions recognized and acknowledged limitations in their ability to make large-scale change within ECE. As such, the stakeholders' prototypes addressed interactional and day-to-day issues that faculty, staff, and students face pertaining to diversity and inclusion. However, because these were issues that the stakeholders had the power to enact, progress has been made. On the other hand, the stronger design culture of BME was reflected by the stakeholders from BME, who recognized both the ability and the need to address large-scale, macro-level diversity and inclusion issues within the school (e.g., defining the organizational identity of BME; redefining recruitment practices, and protocols to address different populations that were missing from the BME student population). In both cohorts, design worked to amplify diverse voices and experiences that deepened participants' understanding of diversity and inclusion. A more in-depth discussion of these results can be found in the [12].

Finding 3 - ECE faculty members' attitudes and perceptions of behavior control and social norms all impact change related to diversity and inclusion. Analysis of ECE faculty interviews revealed that 1) department leadership's visible support was a notable influence on faculty's development of a positive attitude toward diversity and inclusion; 2) faculty deemphasized their roles as teachers because of a perceived norm to prioritize research, which originated from cultural values of the department; and 3) that faculty perceived a lack of behavioral control over diversity and inclusion. The study found that, to produce effective and sustainable change, three factors of attitude, perceived norm, and perceived behavioral control must be addressed together. Failure to do so could not only be ineffective but contribute to more negative attitudes towards diversity and inclusion. A more in-depth discussion of these findings can be found in [13].

Impact of the pandemic

In the following section we detail how the pandemic and attention to racial disparities have impacted each of the research questions, and our ongoing to efforts to understand underlying issues and affect change.

Impact on RQ1. How to make engineering more inclusive?

The pandemic and attention to racial disparities have both exacerbated and illuminated the lack of inclusivity in these engineering programs. It has highlighted inequities in and assumptions about resource availability, such as access to internet and other technological resources, as well as demands to provide childcare and other support to their families during these crises. These significant challenges that many students now face emphasize the need for more inclusive teaching practices by professors, which was one of our initiatives before the pandemic. Recently, we have had to reimagine what inclusive teaching means in a remote learning environment and

given the wide variety of hardships students are facing. Subsequently, we published some inclusive teaching tips for remote instruction that include ideas such as accommodating students with different resources, encouraging students to attend virtual office hours, and being open with students about one's own struggles to forge a stronger connection [13]. Our teaching tips have operated as discussion points for the BME department's action plans to promote more inclusive teaching and culture.

Impact on RQ2. How might we better prepare engineering graduates for practice?

The pandemic and attention to racial disparities have illuminated the relationship between diversity and inclusion efforts and the broader goals of better preparing students for practice. For example, the online/virtual aspect of the pandemic has highlighted the importance of peer social networks to support learning and motivation. It has been a challenge to establish these networks in the online/virtual environment, which has prompted departments to create study group matching programs. This is the case in the ECE department that is part of our study. We are currently investigating the dynamic in this department between students' self-professed need for study groups to get through the program (gathered from our student interviews) and advisors' and professors' perceptions of study groups. While students and many advisors and professors emphasize the need for study groups, some professors question the utility of study groups and worry about their impact on academic integrity. For professors in support of study groups, there seems to be an assumption that students can form these groups on their own, which is evidenced by the lack of a formal matching program previously. However, not all students are able to find study groups themselves (perhaps especially underrepresented students), which puts them at a disadvantage to their peers. The new initiative supporting study group matching highlights this dynamic of underlying assumptions in an interesting way. This work is ongoing.

Impact on RQ3. How might we use design thinking to address complex issues in engineering education?

As the pandemic and race activism have spread throughout the nation and influenced our university and engineering departments, the working groups that emerged from the design sessions were asked to transition to formal Diversity and Inclusion committees and provide new levels of departmental leadership. These new departmental committees, energized by both national and local impetus, are building on our ongoing research and design efforts. They are beginning to address issues that had been identified previously, as well as to identify new social change efforts that can effectively respond to recent calls for action related to racial disparities. The design thinking mindset is encouraging the departments to involve stakeholders in identifying and respond to new needs and issues brought about by online/remote participation on campus.

Conclusions and future work

Our research has identified ways in which student and faculty understandings of diversity and inclusion are impacted significantly by the local contexts of their school and compounded by the larger college, university, and discipline-wide understanding of who is an engineer and what skills legitimize the identity of "an engineer." Currently, we are developing strategies for using design thinking in social change research that could be implemented by other academic programs

to address complex issues in their departments. We are also collecting student survey data to compare students' current perceptions of school climate to those at the beginning of the project. In addition, we have initiated a new phase of interviews and surveys of engineering students and faculty members to understand how the potential additive effects of the viral pandemic and social unrest have on the ability of engineering programs to continue efforts toward increasing diversity, equity, and inclusion in professional formation.

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