Towards a Framework for Equity in Engineering Classrooms

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***Abstract*—This work-in-progress paper presents a rationale for and initial step towards a framework for understanding equity in engineering classrooms. The utility of the framework is conceived as at the interface between theory, research, and practice, where an important theory-and-research-to-practice agenda exists to better understand how to help engineering instructors enact equity in their classroom settings. We contrast our approach with on the one hand decontextualized theory that is not accessible and engaged with by engineering instructors, and on the other with rudimentary best practice that simplify the complex interactions of the classroom into overly simple rules. Instead, the framework we are building towards guides thinking about equity in the engineering classroom. In its current form, the framework 1) draws on equity related social theory, 2) presents dimensions of engineering pedagogical relationships, and 3) identifies components of classroom practice that are involved in everyday engineering education. In future steps, we hope to refine and validate this framework with participant instructors as part of an ongoing collaborative ethnographic research agenda to look at equity in everyday engineering educational settings.**

Keywords—equity, pedagogy, research to practice, theoretical frameworks, ethnography

I. Introduction

This work-in-progress paper addresses a need for resources for engineering instructors to understand equity in engineering classrooms. Much of the broadening participation literature points back to the undergraduate engineering classroom as a primary space where marginalizing culture is created and experienced [1], [2]. Engineering instructors are at the front lines of this marginalization and have a direct role in either recreating or disrupting it, yet comparatively less research has been done on how best to promote equity and transform instructional practice.

One prominent approach to promoting equity in engineering classrooms is to disseminate "best practices" [3], [4], an approach drawn from medical and legal traditions that is meant to simplify and routinize procedures for practitioners. Within educational contexts, these best practices are implied to work in any context and to reduce the instructor role to fulfilling these simple rules (e.g., using multiple audio and visual representations to ensure accessibility for disabled students and language learners, using think-pair-share participation to engage more students than those with raised hands, creating word problem scenarios with a wide variety of gender and racial representations). While these are useful strategies, the negative aspects of a best practices approach to equity include that 1) by drawing on existing practices they can be limited and unimaginative, 2) when some practices do not apply to an instructor's context the list of best practices can be abandoned rather than adapted, and 3) best practices bypass the instructor process of understanding their own educational contexts and thinking about how to proactively shift culture and pedagogy in ways that take on even more ambitious goals.

An alternative approach is introducing theory on equity and inclusion. Theories including culturally responsive pedagogy, intersectionality, and liberatory pedagogy have been introduced via the engineering education scholarly literature [5]–[8]. These theories can help guide the thinking of instructors who engage with them, and in that they are broader ways of conceiving of education rather than a list of rules, they therefore transcend specific settings. The specific theories on equity and inclusion also stem from political and activist traditions, and thus they have the power to critique and challenge the status quo of educational, disciplinary, and institutional norms that exist in the current system of engineering education. Therefore, critical social theory holds great transformative potential for educational culture. Nevertheless, simply disseminating the theoretical literature on equity and inclusion does not help instructors negotiate the practical applications of the theory to specific contextual details, including population, institution, and content area.

This paper represents a progression towards a more useful knowledge and frameworks that help engineering instructors understand the nuances of equity in engineering classrooms. We present a working framework that draws on multiple theoretical and practical dimensions of engineering classrooms, rather than a single dimension.

II. Theoretical Grounding for Equity Issues

This section leverages theory to problematize a simple view of the engineering classroom regarding diversity, equity, and inclusion.

A. Examining Intersectionality

The social theory of intersectionality [9] is often discussed as a theory focused on how Black women experience both racism and sexism [10], or as akin to the multiple identities that individuals hold [11, p. 1]. Yet intersectionality can also be understood as a way of understanding educational systems and culture [12]. Multiple systems of privilege / power and oppression intersect within engineering classrooms and create marginalizing experiences for students, including race, gender, sexual orientation, socioeconomic status, first generation college attendance, gender non-conformity, immigration status, ability, and language learning level. To date, many studies of engineering classroom inclusion emphasize a single dimension, especially binary gender [13]–[16].

B. Creating Culturally Responsive Pedagogy (CRP):

A central claim of CRP scholarship is that curriculum and pedagogy carry cultural frameworks and meanings that can either align with or misalign with students' home cultures [17]. The practice of engineering, and therefore the understanding of the pedagogy of engineering, has historically been aligned around white, middle-class men [18]–[21]. With significant work left to do to explore how to align engineering curriculum with other groups, the need for more instructors to be involved in adapting engineering into cultural responsiveness is high; yet the risk within CRP of essentializing culture or in responding with only superficial educational adjustments is also particularly high [22]. Furthermore, the traditions related to CRP were developed in settings with a relatively homogeneous student culture [23], [24], suggesting additional challenges when students come from multiple home cultures as at most modern universities. Additionally, the persistent demographic patterns of engineering present a fundamental challenge— if an engineering curriculum is responsive to the majority student group culture in a typical engineering course at a Predominantly White Institution (PWI), they would likely perpetuate the gender and racial power dynamics that have pervaded engineering for decades.

C. Deconstructing Meritocracy and Competition:

A prominent and problematic aspect of engineering educational systems is an attachment to meritocracy and competition [25]–[27]. Many engineering courses frame competitions as motivating tools, or have competitive interactions emerge within normal course practices [28]. The downsides associated with competitive culture have been widely noticed in the educational anthropological literature, where competitions require one or a few "winners" and create many more "losers" [29], [30]. In the engineering education literature on student experience, several have identified competition and meritocracy as a source of marginalization for students from underrepresented demographics [1], [2]. And yet, few have examined practices and cultures of meritocracy and competition in pedagogical spaces with a critical lens exploring alternative organizational possibilities. Several research paradigms note the importance of an individual's engineering identity development and positive experiences of self-efficacy, yet few look at the possible unintended consequences of one student's success on another's failure. When looking at interactions we can note how one student's individual identity development and success can have negative impacts on other students in a class setting [31]. We can note a class culture where students are "winning or losing a race" versus one where they are "learning at their own pace."

D. Engaging a Pedagogy of Liberation:

Liberatory pedagogy (or critical pedagogy) grows out of the philosophical work of Paulo Freire, which critiques standard educational practice as a "banking model," doling out the valued knowledge as currency to succeed in an oppressive system [32], [33]. The banking model accords with the standard individualistic neoliberal capitalist goals for engineering education, which attempts to "fill" students with knowledge valued in a capitalist engineering workforce. On the contrary, liberatory pedagogy frames education as oriented towards social justice, where pedagogy liberates students from oppression and upends oppressive systems in the process. A few prominent models exist that explore adapting liberatory pedagogy to engineering content areas that are traditionally understood in terms of neoliberal capitalism [8], [34], yet many more content areas have been unexplored.

Although we do not expect engineering instructors to engage in depth with all of the theories, we orient ourselves using this theoretical grounding to develop insight on equity with engineering educators. Corresponding to each theoretical dimension above, the following questions guide our thinking:

1. How can we hold many intersections of privilege and oppression in view at the same time to build more truly inclusive classrooms?
2. What does it mean to imagine an engineering curriculum that is not steeped in whiteness and masculinity? Whose culture should we respond to and how?
3. Can all students be supported in learning and growth as engineers without some students becoming constructed as failure in comparison to others?
4. How does the curriculum of engineering education pursue liberatory, critical, and justice-oriented practice within subject matter traditionally nested within neoliberal capitalism?

III. Practical Dimensions of Engineering Pedagogy

In addition to the leveraging of theory, we consider implicit dimensions of classroom practice, and the particular challenges that can emerge regarding equity.

A. Expanding Faculty Noticing and Learning

Faculty are key influencers of undergraduate engineering education equity and inclusion, yet concerted effort around faculty development is often left to ad hoc workshops and webinars. In broader K-12 educational scholarship, the dimensions and phenomena that teachers notice and how they make sense of these phenomena are important elements of teacher professional development, since understanding one's

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own classroom is a crucial step in crafting appropriate and responsive curriculum and pedagogy [35]. In parallel conversations, diversity and inclusion scholars highlight the importance of identifying one's learning edges regarding dimensions of inclusion [36]. Perhaps a female STEM faculty member has an intuitive understanding about gender equity, but is unsure or unaware about issues of racial equity or disability, and unsure how to make progress. Identifying this as a learning edge helps to keep channels of growth open instead of stymied by retaining a sense of safety.

B. *Addressing Faculty/Student Identities and Positionalities*

Faculty embody certain identity perspectives and are perceived by students in parallel ways. Students as well carry certain identity perspectives and embody certain demographic populations, background experiences, and generational perspective. These are not in the control of faculty but do influence the perception and reality of inclusion and equity in classroom settings. Faculty with relative privilege who are unfamiliar with diversity and inclusion issues may not recognize their own positionality regarding their students, and what impact it is having.

C. *Acknowledging Course Context and Institutional Constraints*

Finally, several course particularities and institutional constraints are present in and underlying any classroom. The content area and curriculum may have a tradition associated with instructional practice, and this may be tied to Accreditation Board for Engineering and Technology (ABET) accreditation procedures or institutional stipulations. Faculty may be teaching in large multi-section courses with a shared curriculum, or they may have discretion over their smaller course but have to justify their course development process to other institutional stakeholders. Pre-tenure faculty may feel additional pressure to ensure good course reviews, while post-tenure faculty may have developed conservative pedagogical habits through the process. As noted, the differing institutional contexts at PWIs and Minority Serving Institutions (MSIs) may create real or perceived constraints regarding resources and possibilities for equity and inclusion. Constraints like these can produce conservative and status quo approaches for equity and inclusion, yet with additional creative thinking acknowledged constraints can lead to novel forms of practice.

The following questions guide our thinking on the dimensions of engineering pedagogy.

1. How can we help faculty notice further dimensions of equity and inclusion and lean into their own learning edges to transform their practices in increasingly ambitious ways?
2. How will faculty reflection on their own and students' respective identities, perspectives, and power relationships increase understanding and initiate change in their classes?
3. How can instructors uncover and address institutional constraints and contexts in order to think and act creatively and ambitiously about equity and inclusion within and beyond those constraints?

IV. Components of Classroom Practice

In addition to theory, we note the specific areas or components of classrooms in which equity issues can emerge. These aspects (Fig. 1) can be seen as areas to encourage faculty noticing and areas in which the previous theoretical dimensions can play out. Some initial insights into the equity issues involved in these components are demonstrated in Figure 1.

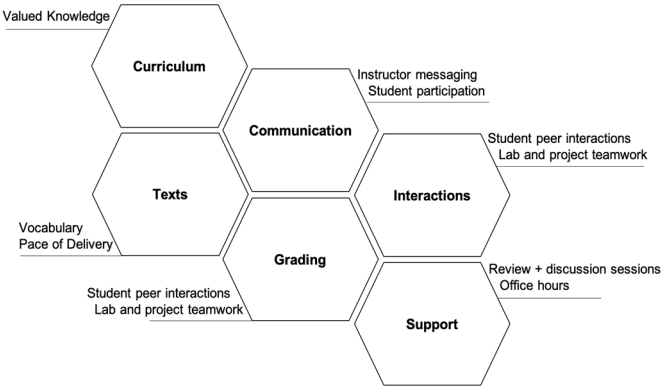

Fig. 1. Components of Classroom Practice.

V. Conclusions and Future Work

As discussed in the introduction, the challenges with "best practices" frameworks are the level at which we aim "best practice" work (e.g., at individual decontextualized actions) and the focus on singular components of a classroom experience (e.g. classroom participation, curriculum, gender). The purpose of this theoretical contribution to engineering education scholarship is to highlight and reinforce the intersecting elements that affect engineering classrooms beyond simple instructor practices.

This paper represents progress towards a framework that could be leveraged by both engineering education researchers and engineering instructors concerned with equity. Further work is needed to validate the framework as a pedagogical tool by placing it in an interactive research study with engineering instructors. We plan to conduct a comparative critical ethnography of engineering classroom spaces with multiple institutions and instructional / curricular contexts, using this framework as a tool for orienting both researchers and instructor participants.

Acknowledgment

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