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Re-Situating the Professional Formation of Engineering Identity

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Re-Situating the Professional Formation of Engineering Identity

1. Introduction

In this paper we present results and current progress in re-situating the professional formation of engineering identity of students in the School of Chemical, Biological, and Environmental Engineering at Oregon State University. We aspire to establish a more inclusive, and professionally-based learning environment for our domestic and international students that better facilitates their understanding of and skills to navigate the world of engineering culture and practice. We are working in our School to bring about change through establishing a culture of inclusion and a shift in student learning environments from highly sequestered activities to more realistic and consequential work that is more typical of the actual engineering workplace [1]-[2].

In this third year of our project our work is focused on: (1) broadened faculty training and engagement in implementation of curricular redesign in a number of studio classes to include more realistic, consequential work; (2) establishing a faculty and staff professional learning community focused on issues of equity and inclusivity, including best practices for inclusive teaming in our courses; (3) working to better understand the overall climate and culture of our School, especially in relation to undergraduate student progression towards degree completion (or conversely loss of students from our programs) and student identity formation; and (4) continuing to establish systems and a culture for faculty and staff that better recognizes and rewards less-traditional work that values and advances diversity, equity, inclusion, student success, and school community.

This work is supported by the National Science Foundation program *Revolutionizing Engineering and Computer Science Departments* (RED) that is aligned with the NSF Engineering (ENG) Directorate's multi-year initiative, the *Professional Formation of Engineers*, to create and support an innovative and inclusive engineering profession for the 21st Century [3]-[4].

2. Current Progress

Curricular Change in a Core Curriculum –

Our approach to curricular changes centers on meaningful, consequential learning in nine core studio courses. In this approach, we seek to position students in the role of engineers where they recognize core foundational principles as conceptual tools that enable their work [5]. We draw upon Engle and Conant's framework [6] of productive disciplinary engagement to describe engineering students use of concepts, practices, and discourses of engineering to "get somewhere" (develop a process or product, gain better understanding) over time. More detail on the theoretical framing of our approach is available in Koretsky [7].

Implementation centers around ten core "studio" courses, including: Material Balances, Energy Balances, Process Computations, Process Analysis, Thermodynamics I and II, Fluid Mechanics, Heat Transfer, Mass Transfer, and Chemical Reaction Engineering. In the studio structure [7] large lecture sections (100 - 350 students) are interspersed with smaller studio meetings (approximately 24 students). In studios, students work together in mostly 3-person teams, facilitated by trained graduate student teaching assistants (GTAs) or the course instructor. We are also integrating the use of trained undergraduate learning assistants as well.

In this project, we seek to shift from the "Studio 1.0" model to a "Studio 2.0" model. In Studio 1.0, activity relied on sequestered, worksheet-based problems that helped students identify and practice key conceptual and procedural knowledge, and connect that understanding to lecture. The emphasis in Studio 2.0 is to shift the work to activities where students can better identify themselves as developing engineers. Our approach is to situate the task as in a professional scenario and pose it as a single integrated engineering problem where learners take the role of professionals who are engaged in engineering practices while working on a team. The orientation is practice-to-concept where we create tasks that have students use core concepts and practices as tools in the context of real (and messy) engineering work.

In the first two years of this project, we worked on developing model studios in several courses and on collecting data to enable iterative design improvements. In project year 3, an additional objective has been to move forward towards shifting faculty in all studio courses to this new model through developing a Studio 2.0 community of practice. This community has evolved as follows. In 2016-2017, a core group of selected studio course instructors convened regularly to develop a set of Instructional Design Principles for Studio 2.0 in alignment with the goals of the greater change initiative. In summer of 2017, all studio instructors were invited to participate in a week long intensive workshop that was facilitated by two learning scientists with deep knowledge in instructional design for ambitious, equitable instruction. Instructors from eight studio courses were able to attend. Work centered around building understanding of pedagogical practice and on leaving the workshop with at least one Studio 2.0 course activity for 2017-18.

To help faculty develop activities that incorporate meaningful aspects of practice, we developed a material tool for planning and explaining, shown in Figure 1. This "quad design tool" asked instructors to identify the context and engineer's role in considering the activity design. It also explicitly distinguished between the concepts and engineering practices that students were intended to engage in. The material tool helped to ground the theoretical ideas in the practical work of activity design, as evidenced by the interactions of the participants. Those faculty who were enculturated through their participation in developing the instructional design principles often took on leadership roles in moving the group thinking forward.

Finally, during fall term, a two-hour community meeting was convened that included most of the summer participants and the three studio faculty who could not attend in the summer. After a round table discussion from the fall studio instructors about aspects of implementation, participants broke into groups and watched a video recording of students participating in a Studio 2.0 activity while responding to questions on a shared whiteboard. There was active discussion as faculty struggled with the aspects of confusion that were inevitable as students made sense and progress on the realistic task in the video. It was clear that some were expecting students to go straight from the task assignment to the correct answer (like an example on the board). We view this productive friction as essential in shifting views about teaching and learning towards the goals of the project. Some of those who participated in the summer workshop took leadership roles as the discussion was forming. We plan to continue similar meetings with this community of practice every term.

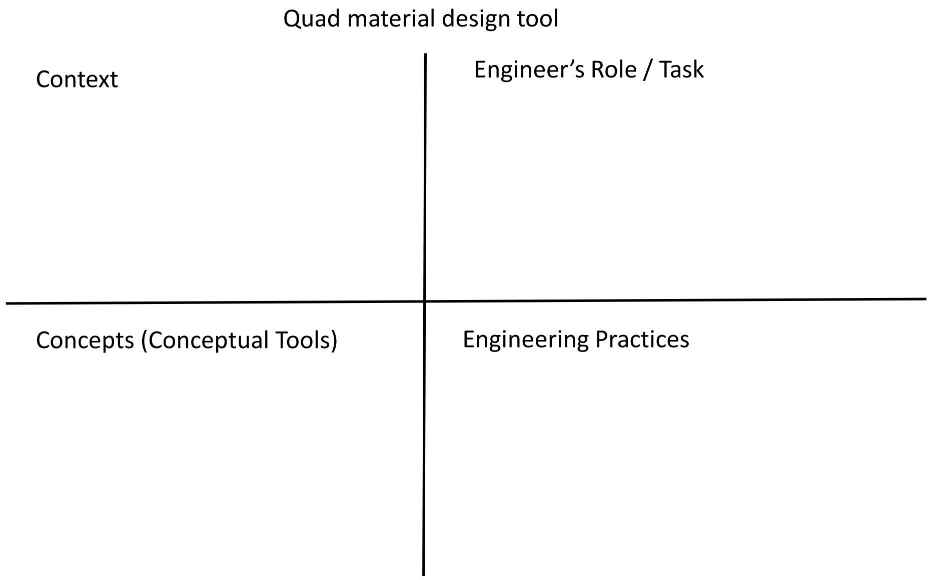

Figure 1. Material tool for Studio 2.0 design.

Focus on Issues of Equity and Inclusivity –

Data from initial implementation of a School-wide undergraduate student climate survey showed that respondents across the board were cognizant of differences in how welcoming School climate is for students from dominant vs. non-dominant groups, and that perceptions of climate appeared to predict persistence and identification with engineering, along with students' gender and race [8,9]. The effects of gender and climate on these outcomes were mediated by the extent to which students felt respected and connected to peers. A focus group study, conducted in parallel to survey administration, recorded similar trends [10]. Students from dominant groups conveyed a strong sense of belonging in the unit, while international students and students of color generally expressed a lower sense of belonging. Contradicting sets of student perceptions arose from the data as well. For example, a commonly expressed theme in the focus groups was the relative sense of gender parity in our engineering programs, but participants across the board consistently shared experiences of gendered microaggressions. Taken together, these results support our efforts to promote inclusive teaming practices and efforts to make School climate more inclusive [11]. Administering the climate survey annually to all undergraduates will allow both cross-sectional and longitudinal analyses, supporting a tracking of the impacts of specific changes to School-wide practices.

Research in Organizational Change -

Using a design-based implementation research (DBIR) approach implementation "problems" and "successes" provide important information for redesign and elaboration decisions [12]-[13]. Our ongoing analyses are currently being used to inform design decisions. The Studio 2.0 progress described above provides a good example of this. Based on observations of student engagement during the early versions of studio tasks, a group of faculty began meeting to develop design principles for studio tasks that would more fully immerse students in engineering tasks. Video data were collected from volunteer students to explore the ways in which students engaged studio tasks. These data informed the summer workshop for faculty to design Studio 2.0 tasks for their courses based on these shared principles and on additional work on inclusive teaming. Video records of student engagement in these tasks continue to inform ongoing work with this group, who have coalesced into a Studio Community of Practice described earlier.

We are continually comparing data from before initiation of our project and from early phases of project implementation to that from later phases, in the following areas: teaching approaches and learning environments in studio courses, climate and inclusiveness, opportunities for students to make sense of a variety of engineering spaces and their associated climates, and structural changes. In making these comparisons, we will attend to changes in the activity systems involved (School-level, College-level, University-level) and to the participation and perspectives of faculty, students, and staff. Of particular interest are mechanisms for supporting ongoing work and change after the grant period.

Overall, research activities to date include baseline and mid-project interviews with most of the faculty in the School, advisors, and key staff members; interviews with entering and graduating students about their social and academic experiences in the School; observational data collection at School faculty meetings and workshops; surveys of entering and graduating students; the development and implementation of the annual School-wide climate survey for undergraduate students, and video recordings and student surveys of reform and older studio activities. These data are being analyzed and findings will be used in further planning and decision-making.

3. Summary and Future Work

In summary, our work in this third year of our project has been focused on steps towards establishment of a more inclusive, and professionally-based School and learning environment for all of our students that better facilitates their understanding of and skills to navigate the world of engineering culture and practice [14]. A primary outcome we seek through our work overall is the enhancement of both students' and faculty's capacities to engage issues of inclusivity, equity and social justice. Towards this end, we aspire to shift School community members' cognitive and affective knowledge of power and privilege. While there are quantitative assessment tools that measure related constructs (e.g. cultural competencies), we are not aware of any instruments that measure a person's understanding of social power and oppression, particularly how socially constructed differences and identities like gender, race, and class intersect and combine to affect people's lives in various settings. Our research team is in the early stages of constructing such an instrument, and will begin piloting it soon to test for reliability and validity.

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