Re-Situating Community and Learning in an Engineering School

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1. Introduction

In this paper we present early results and ongoing work in re-situating the faculty/staff/student community, and curricular/co-curricular student learning experience in the School of Chemical, Biological, and Environmental Engineering (CBEE) at Oregon State University. Our work is centered on the creation of a holistic, inclusive, and professionally based learning environment for our students. We seek to address social inequality through implementing engineering educational systems and cultivating interpersonal interactions that are professionally and personally life-affirming for all of our constituents. We are working to promote change through establishing a culture of inclusion and shifting student learning environments from highly sequestered activities to more realistic and consequential work that more closely resembles actual engineering workplace. These efforts require an important and concurrent shift in unit culture (e.g. values, norms, policies and procedures).

Our project is structured around four pillars:

1. Curricular redesign and implementation of second- and third- year studio classes to include more realistic, consequential work via situated pedagogies like model-eliciting activities and problem-based learning;
2. Advancing faculty and staff capacity to engage issues of equity and inclusivity under the leadership and efforts of several new faculty/staff/student working groups;
3. Implementation of student professional development ‘Pods’ (self-forming student teams structured to be highly inclusive) where students can convene to better understand their curricular and co-curricular experiences in relation to future professional practice; and
4. Implementing a system for change in faculty/staff personalized position (job) descriptions in order to recognize less-traditional work that values and advances equity, inclusion, student success, and school community.

In this paper, we describe progress and challenges in each of the pillars. 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.

2. Theory of Change

While our school has already implemented innovative curriculum and has a rich and varied array of co-curricular activities, the professional development of engineers operates within the larger culture of engineering as practiced in industry. We have proposed that we must attend to this larger context, including improved inclusion of people from under-represented groups, in order to enact revolutionary departmental change. The activities in our project address course design, pedagogies, organizational structures and policies, faculty/staff/graduate student culture, and undergraduate student culture. An important recognition in our work is that all of these components interact with the others. We have proposed that if our efforts will affect lasting
change, we must simultaneously re-situate and re-negotiate these multiple components. Activity theories provide both an explanation for the ongoing existence of departmental norms and practices and a framework for inducing change. These theories "situate" individual learning and activity in the social contexts in which they occur. Indeed, it has been argued that a situative approach is needed to address the complex professional development of engineers. By taking a situative approach, we consider activity systems as continually co-constructed through practice, and consider the roles of individuals and organizational structures, policies, and rules in maintaining and disrupting the status quo.

3. Curricular Change in Core Courses

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. We draw upon Engle and Conant's framework of productive disciplinary engagement to describe engineering students use of concepts and discourses of engineering to "get somewhere" (develop a process or product, gain better understanding) over time. For the curricular design, we draw upon pedagogies that seek to embed learning through working in real contexts, including Problem Based Learning and Model Eliciting Activities. More detail on the theoretical framing of our approach is available in Koretsky et al.

Implementation centers around nine core courses, including Material Balances, Energy Balances, Process Computations, Process Analysis, Thermodynamics I and II, Fluid Mechanics, Heat Transfer, and Mass Transfer. Enrollment for 2016-17 in these courses ranges from approximately 150 to 250 students in lecture, but students also meet in accompanying studio sections of 24 students or less. The work described here focuses on the studio portion of the courses. We chose the studio courses, in part, because they are structurally ready to shift to these pedagogies. In studios, students actively apply concepts and problem-solving procedures as they work in teams. Learning in studio is supported by graduate teaching assistants and instructors who interact with students in a facilitative rather than directive manner. The emphasis on the reform is to shift the work in studio from “work sheeting” 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 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 project year 2, we have moved forward towards shifting faculty to this new model. A schematic of the project activity is shown in Figure 1. We are addressing two key areas: (i) developing studio activities and (ii) developing instructional practices. While we have faced the challenge in having busy faculty recognize the value of spending time creating new learning activities, we are making steady progress.
To this end, we have focused on:

- **Instructional Design Principles.** We have convened a set of six core instructors to write an initial draft of Instructional Design Principles for studios. These include: Practice First; Group Worthy Problems, Looping, Cooperative Learning; Assessment; and Manageable Change. These will next be taken to the larger set of studio instructors for further development and consideration.

- **New Studio Activities.** We have developed and implemented seven new studios to date over the sophomore-level sequence. Two of these are based on virtual process simulations where each of the teams gets a unique data set that is different than any other students in the class.

- **Instructional Practices.** We have implemented a Learning Assistant (LA) program based on the Colorado Learning Assistant Alliance (https://www.learningassistantalliance.org/). The LAs provide additional support in studio to facilitate learning and also provide a “near peer” for teams’ reference. LAs have been used in four studio courses over the last three terms. We have also instituted a Graduate Teaching Assistant (GTA) professional development program that includes a half-day workshop before the academic year and eight one-hour seminars over the year. Central to both development programs is work around inclusive teaming practices that allow the LAs and GTAs to identify and address status interactions of team members.16

- **Improved Studio Space.** We have worked with the Registrar and the University Space Committee to develop two adjacent classroom spaces for studio delivery. These spaces have movable tables, large workspaces where students can write and have computer or text resources, and allow the course instructor to visit two studios at the same time. Having a well-designed space that we can count on has been an important improvement.

- **Data Collection.** Data collection consists of observation, videotaping, student performance data, surveys, and focus groups. We videotaped four teams in a clinical setting for a two-hour studio problem solving task. We have also videotaped teams in a classroom setting with both the old and new studio designs. A survey of students in the
2nd year Process Analysis class was conducted, and a focus group of students was held in the summer. Analysis of these data are pending.

4. Creating a Culture of Inclusion

The creation, maintenance and propagation of norms, beliefs and practices that underlie engineering disciplines depend heavily on engineering educators and engineering practitioners. Thus, our approach to shifting the culture within our unit has included significant professional development opportunities aimed at enhancing faculty members’ awareness of institutionalized systems of inequality and privilege. For a more detailed explanation of these development opportunities, please see Koretsky et al. 15

By fall 2017, sixteen of twenty-nine CBEE faculty members with significant teaching responsibilities will have completed a 60-hour educational experience that encourages examination of how unequal distribution of social, political and economic power becomes enacted in day-to-day personal interactions. This experience also provides background needed for developing a more sophisticated and nuanced understanding of structural inequalities, and is designed to provide faculty with a common language and a critical lens from which deeper conversations within our CBEE community can be facilitated. There is an expectation that faculty who have participated in these opportunities will apply their knowledge and new understandings of difference towards advancing transformation through actions to create change within their spheres of influence.

Multiple faculty-driven projects have emerged from the 2016 CBEE taskforce on equity, inclusion and social justice. Three examples of ongoing projects are described below.

- Inclusive and Socially Just Teaming Practices. The goal of this project is to develop faculty capability to design and implement processes to develop students’ capacities to engage in inclusive teaming, where diverse voices are encouraged and valued. Towards this end, a professional learning community is being planned to provide a facilitated opportunity for extensive inquiry-based faculty development around the design of instructional content, pedagogy and assessment metrics for inclusive and socially just teaming practices. This work will extend and support the LA and GTA development programs discussed above. This community of seven instructors (all of whom will have completed the 60-hour development experience described above) will meet throughout the 2017-18 academic year, exploring scholarship on evidence-based practices for promoting effective and socially just teaming and using this as a platform for adaptation and integration of these practices into our undergraduate courses.

- CBEE Graduate Curriculum Development. The goal of this project is to design and implement curriculum that will engage the CBEE graduate student population in the intellectual examination of the complexity of structures, systems, and ideologies that sustain discrimination and the unequal distribution of power and resources in society, with particular attention to the importance of representation in engineering education and practice. Towards this end, four faculty members, four graduate students and one undergraduate student collaboratively developed four introductory modules that were delivered through the required CBEE graduate seminar in the 2016-17 academic year.
These modules included content on the relevance of difference, power and privilege in engineering, cognitive bias, stereotyping, binary thinking and the conceptualizations of interpersonal and institutional power. This student/faculty team will record data through surveys and interviews over the coming months to inform development of a more strategic and in-depth exposure to these topics for the graduate students entering CBEE in the 2017-18 academic year.

- **College of Engineering (COE) Change Team.** Four CBEE faculty were selected for a College-wide initiative aimed at empowering faculty and staff to serve as Change Leaders within their units and the college. The initial scope of this project includes participation in a 6-day faculty development workshop toward the end of gaining content knowledge and skills needed to facilitate two, 2-hour seminars on diversity, equity and inclusion topics. The intent would be for all employees in the College of Engineering to participate in the two seminars over the next couple of years. It is imagined that a number of those on the COE Change Team will become involved in transforming their units through alternative mechanisms as well. For example, a COE Change Team member from CBEE has proposed a project within our unit to explore the noticeable divide between our School’s domestic and international student populations, with the eventual goal of reducing this gap.

The three activities described above, and others like these, promote discussions and actions that move us towards more inclusive classrooms and a more just climate. The approach of engaging a significant number of individuals in these transformative efforts aligns with evidence that shows change to be more likely when responsibility for transformation lies with all individual community members rather than relying on a dedicated few.¹⁷

### 5. Student Pods

The Student Professional Development Pods are intended to be safe, inclusive spaces where students can discuss issues pertinent to their developing professional and personal identities. In particular we hope that students will use these spaces to note and discuss the different ways their identities are expressed or hidden in different settings. As we work to revolutionize our School culture, for example, we may establish norms and practices that are uncommon or unknown in some professional communities. The Pods are intended to be a place where students can share their experiences of such spaces and develop a shared understanding of how to navigate the potentially conflicting value systems they will encounter. See Koretsky et al. for more information on the theoretical framing of Pods.

Because pods are intended to be self-sustaining and student-centered, we sought student input into their design. We recruited students from the second, third, and fourth years in CBEE to participate in a 6-week summer work experience. Sixteen students expressed interest in the position and participated in interviews. We invited all students to participate in order to set an inclusive norm and to bring a broad perspective to the work. The students participated in approximately 3 weeks of professional development (including readings, discussions, activities and writing) concerning difference, power and oppression, as well as 1 week of development in curricular design and engaged learning strategies.
Once the student designers understood the project and the role of Pods, they formulated their design in terms of structure and autonomy. The consensus was that the Pods need to be as flexible as possible to allow new Pod members sufficient authorship in forming the community’s norms and practices while still achieving the Pod’s purpose. The student designers distilled that purpose into four key goals. In the students’ words, every Pod must seek to:

- **Encourage holistic personal development**: When asked what support or resources were most lacking in their engineering education experience, the students agreed that the most salient lack was in terms of their mental, physical and emotional well-being. They had all felt a pressure to center their lives on engineering study and largely exclude or devalue their physical, emotional and social needs. They hoped Pod discussions would address stress management, metacognition and emotional resilience.

- **Create an inclusive environment**: Beyond acknowledging or “tolerating” the differences among people, the students wanted the Pods to be actively welcoming to groups or identities that are minimized or invisible in engineering.

- **Support understanding of engineering skills**: The student designers knew that, for many students, engineering education is centered on the development of engineering skills and competencies. They therefore saw a need for the Pods to help students integrate the development of their technical skills with the other goals of the Pods. Toward that end they included engineering skill development into the pods’ design so that, for example, pod members could work together to study for an exam while practicing holistic self-care.

- **Develop an understanding of the engineering profession**: Similarly, the student designers wanted the Pods to support members’ learning about the engineering profession, and then relate that understanding to their own developing understandings of themselves and others.

The designers planned recruitment practices so that students could be identified, grouped and engaged in Pods as quickly as possible and with minimum time or commitment from the potential recruits. During fall 2016 the student designers visited four courses and spoke individually with each student to invite them to participate in the Pods. This approach was time-intensive, but it reached nearly all sophomore-, junior- and senior-level students. The face-to-face interaction was also intended to be a demonstration of how Pods were different from other student clubs and activities – instead of a general email to thousands, or a brief presentation to dozens, the student designers demonstrated an ethic of care by speaking individually with each student.

The new Pod members would be equally distributed, and each new Pod would include at least two members of the student design team to serve as seeds of the desired community norms and practices. During the first term the Pods were expected to meet 2-5 times to agree on their own methods of achieving the four Pod goals. While the student designers developed materials and examples of activities and practices that were likely to achieve the goals, none were specifically required. This allowed the Pods the flexibility to develop individually, informed by the people participating.
We have also been fortunate in our unit to have a highly engaged Industry Advisory Board (IAB) that we have enlisted in support of our RED project work. During our fall 2016 meeting several IAB members expressed interest in engaging with students in support of the RED project goals. During the meeting we developed the concept of “matching” IAB members (and other interested alumni) as mentors with student Pods. The matching would be based on mentor and Pod-members’ career directions and experiences, and more generally on their life stories, challenges, and accomplishments.

The student designers have continued to interact with each other in what they refer to as a “superpod” (both because it is larger than a typical pod and because it includes representatives from every other pod). Although nearly 80 students expressed interest in the Pods less than 15 attended initial Pod meetings. We suspect that participation is deterred in part by the strong other club activities already in place in the unit. Student feedback suggests that interest remains high, but the make-up, purpose and expected level of commitment to the Pods in unclear. We are currently restructuring the Pod recruitment practices to include more structured, directed activities and commitments for the first few terms.

6. Structural Changes in the Unit

We have anticipated that changes to unit policies, procedures, and practices will be required in order to recognize and explicitly value the work of faculty and staff in our transformation efforts, especially where such work is outside of traditional norms and practices. This is especially true for faculty who are not yet of full rank. We are fortunate that Oregon State University bases review of all employees, including faculty, on individual position descriptions (PDs). See Koretsky et al. \(^{15}\) for more details on how we foresee personalized position descriptions as an important lever for our work that has the potential to place responsibility for culture transformation on each faculty/staff member of our community as opposed to relying upon the efforts of a dedicated few.

Much like at many academic institutions, faculty at OSU undergo annual performance evaluations. In preparation for evaluation by their supervisor (in this case the CBEE School Head, who is also the PI on our RED project), each faculty member prepares a summary report of their activities and contributions in the past year. This report also should include reflections on results achieved versus goals from the prior year, as well plans for the upcoming year. An underused feature to date of the annual evaluation has been a consideration of content of the current position description, with changes and updates to be discussed and agreed upon with the supervisor. We are pursuing customization of position descriptions as a tool to engage faculty and staff in our unit reform activities, enabling individuals to better see and agree upon contributions that they are interested in pursuing (or have already).

In anticipation of this increased emphasis on the use of position descriptions in the review process, we conducted two half-day workshops for faculty and staff in the summer of 2016. The workshops focused on collective discussion centered on the following two questions:
1. “What do you already do/work on that could be included in your position description that would more clearly illustrate contributions to diversity/inclusion/equity/student success/community?”
2. “What would you like to work on in the future toward the same contributions?”

The results were catalogued and over 150 ideas emerged from faculty on how they might already be making contributions to the advancement of inclusion, equity, student success, and/or community – or could in the coming year. We are in process of identifying ways to formalize such contributions in the annual review summaries so that they can then constitute a specific expectation(s) documented in personalized faculty position descriptions.

7. Research in RED

Using a design-based implementation research (DBIR) approach\textsuperscript{18,19} implementation “problems” and “successes” provide important information for redesign and elaboration decisions. Our ongoing analyses are currently being used to inform design decisions. Development of the Pods provides a good example of the DBIR process. By recruiting undergraduates in CBEE to help develop the design approach, we were able to learn from them more specifically how Pods might support students, both in terms of social and emotional well-being and professional development as engineers. Lower than expected turnout to initial Pod meetings has led to a re-analysis and redesign of the approach. However, while that goal was not fully achieved, we also gained an important student perspective on studio implementation from the work with Pod students that has been incorporated in the studio redesign efforts (e.g., assessment protocols shifted to engagement and participation rather than the “product” of the studio work). Other examples may be found in the sections above for each “pillar” of our RED reform effort.

We are continually comparing data from before RED and from early phases of RED 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 (CBEE, College of Engineering, OSU) 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.

We also held the first meeting of our project Educational Advisory Board this year. Members of the board represent deep expertise in engineering and STEM education, organizational change, and perspectives from industry (both alumni and non-alumni). A main goal of this meeting was to seek the advisory board’s input on strategic and operational choices to be made by the project team. We also sought to provide a foundation to support an ongoing conversation with board members. In particular, we sought the board's specific, actionable recommendations towards:

- Continued implementation of the four “pillars” of our project, including identification of synergies and tensions between pillars;
- Catalyzing organizational change throughout the inter-connected activity systems of our CBEE School, and
- Understanding and progressing our work through the aforementioned design based implementation approach.

Overall, research activities to date include baseline interviews with most of the faculty in CBEE, advisors, and key staff members; observational data collection at CBEE faculty meetings; surveys of entering and graduating 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. Focus group data with undergraduates interested in the development of Pods and initial planning data have also been collected. An annual CBEE climate survey of all undergraduate students, with the capability of disaggregation for various subgroups, will be initiated in spring 2017. Administering this survey annually to all undergraduates will allow both cross-sectional and longitudinal analyses, supporting a tracking of the impacts of specific changes to CBEE practices. Outcomes such as intention to stay or leave engineering along with reasons for doing so will be measured and related to measured climate variables.

8. Summary

In this paper, we have described progress in the second year of our RED efforts in CBEE in which we have worked to re-situate instruction and learning to create a more inclusive, professionally-based learning environment woven throughout both curricular and co-curricular experiences for students. Within our design-based implementation research approach, it is difficult (and perhaps unwise) to specifically envision how the activity systems in CBEE will be transformed by the end of this five-year project. We do, however, aspire to compiling, assessing and evaluating evidence over time that will enable us to address the following aspirational questions:

- Does everyone in the CBEE community feel they are valued and that they belong?
- Do students meaningfully connect curricular and co-curricular activities and experiences to each other and to professional practice?
- Is work in “the Core” sophomore and junior level courses and throughout the curriculum connected to solving real-world problems and the broader set of social, economic, and political contexts within which engineering work is done?
- Do students have structured opportunities to make sense of the climate of engineering workplaces in productive ways?
- What processes and perspectives effectively catalyze change in the School activity systems? Which are potentially replicable by other departments?
- What is the evidence that an activity systems approach facilitated change, e.g., is there evidence that attending to systems-level interactions provided benefits that a focus on individual components would have missed?
- What features of CBEE activity systems and structures (belief systems, departmental values, student and faculty histories) enabled or obstructed changes? How were they addressed and overcome? What barriers remain?
- What are the mechanisms that will sustain the work after the granting period?
- How can professional development student Pods (or similar structures) be developed and grown to provide access for all students in CBEE?
Ultimately, we aspire to both transform the activities systems in CBEE and to serve as a model for others in engineering education as we move towards an inclusive and creative engineering profession for the 21st Century.

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