Revolution in CBEE: Sustainability and Barriers

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Introduction

Supported by an National Science Foundation Revolutionizing Engineering Departments (RED) grant, the School of Chemical, Biological, and Environmental Engineering (CBEE) at Oregon State University seeks to create: (1) a culture where everyone in the CBEE community feels a sense of value and belonging, and (2) a learning environment that prompts students and faculty to meaningfully relate curricular and co-curricular activities and experiences to each other and to connect both with professional practice.

There has been substantial activity in support of these goals. Approximately two-thirds of the School faculty have completed a 60-hour professional development experience that encourages examination of how unequal distribution of social, political and economic power becomes enacted in day-to-day personal interactions. About half the faculty have been involved in our Studio 2.0 transformation where assignments are crafted to position students in the role of teams of engineers doing realistic work.

In the final year of the grant, we are investigating the ways that shifts in structures and practices have been taken up by the community and identifying barriers to sustainability. This paper discusses four structural changes in support of these efforts: a Learning Assistants (LA) Program, a climate survey, the Alternating Leads co-teaching model, an innovative first-year problem solving and community building elective course, and modification of position descriptions in support of change. The examples were chosen based on differences in community support towards sustainability. Our hope is not just to communicate what has worked well but also the types of barriers that resist shifts in organizational structures.

Framework

Our theory of change is built on social practice theory (e.g., Bourdieu, 1977; Engeström, 2001; Greeno, 2006; Holland et al., 1988; Lave & Wenger, 1991), which situates individual learning in the social contexts in which they occur. We focus on the influences of "school culture" on pedagogical and curricular norms and ways to better align those norms to the engineering practices in which professionals engage (Jorhi, Olds, and O'Conner, 2014). Specifically, we appropriate Sawyer and Greeno's (2009) concept of situative learning to identify how we can "re-situate" the activities and practices in CBEE to move towards the inclusive, integrated and holistic learning environment that we envision. We view this design as an on-going process among a structure that contains two fundamental elements: a culture of inclusivity and realistic, consequential work.

Learning Assistants

The first example centers on the use and professional development of near-peer Learning Assistants (LAs) to facilitate interactive engagement in a studio class environment (Koretsky et al., 2018). The LA Program utilizes the three core elements suggested by the *Learning Assistant Alliance* (Otero, Pollock, & Finklestein, 2010). First, LAs receive pedagogical development in a formal class with their peers in their first term as an LA. Second, LAs meet weekly with the instructor and the graduate teaching assistants as a member of the instructional team to prepare for active learning in class. Third, LAs facilitate active learning in the class in which they are assigned. Each week in the pedagogy class LAs are posed a specific prompt that connects to specific reading and asks them to reflect on their learning and practice in writing. This process is intended to help them connect the three program elements and build a broader understanding of their own learning and pedagogical practice. It also provides the instructor of the pedagogy course specific ideas and real experiences to draw upon for class discussion. The content and structure of the LA pedagogy class allow development towards the two ideals of the RED project: a culture of inclusivity and realistic, consequential work.

This LA initiative is supported broadly within the community and is well on its way towards institutionalization and sustainability. A formal School-wide application process has been developed where all students have opportunity to participate, not just those who ask a particular instructor. Selection of the cohort is made on a holistic basis looking at factors such as academic skill demonstrated, stated value and motivation to be an LA, perspective they bring to the group, and having a disproportionate population of students underrepresented in engineering. The pedagogy course has been through several iterations and has moved from a course delivered across several schools in engineering to one that is specific to the studio structure and RED project values in CBEE. A pair of CBEE faculty have been identified as instructors and taken ownership of its delivery. A technology-based tool has been developed to facilitate reflection and instructor feedback of those reflections (Koretsky et al., 2014; Koretsky, 2020). The LA program continues to develop and within the past year the following aspects have shifted: teaching credit for faculty delivering the LA pedagogy course; greater faculty ownership and administration of LA recruitment and hiring; and the integration of a Lead LA position.

This academic year, 24 undergraduates successfully completed the LA pedagogy course in the Fall, and LAs have been used in 12 different courses during Fall and Winter terms. The use of undergraduates in support of learning has a rich history in the School, and re-situating the nature of their work and providing more specific support appears to align with community conceptions. For example, these efforts are bolstered by frequent hallway conversations with both faculty, LAs, and the students they serve expressing enthusiasm about the benefit of using LAs. Administratively, there was already a commitment to use and support undergraduates in delivery of instruction. There was not an objection to resituating their use. However, there was additional overhead to support the hiring process. In addition, the grant provided support for the pedagogy class in the form of a stipend. This support will not be tenable after the grant period. Fortunately, the university has recently implemented the construct of a "non-credit" course for high-impact experiential learning. We are in the process of approval of a LA pedagogy non-credit course.

Climate Survey

We have developed a survey instrument to assess student perceptions of climate (Davis et al., 2018), and delivered the survey for the third year. The plan is to have the survey be a continued program level assessment measure of School climate. This year, we collected 645 additional responses, with 529 participants consenting to using their responses for research; only consented responses are represented here (results did not differ from total sample). As in previous years, the climate survey revealed that while students perceived the School climate as generally welcoming, students from all social identity groups rated the climate as significantly more welcoming for students from dominant (white, male, US-born) than non-dominant (all other social identities) groups. 64.9% of respondents indicated that the School climate is improving. Both quantitative survey analysis and qualitative analysis of open-ended responses on the survey highlighted the importance of peer relations in students' perceptions of climate and engineering identity. Respondents intending to remain in engineering (93.8%) rated intrinsic reasons for staying, such as interest in engineering work and impact on the world, as more important than perceived fit or extrinsic reasons (all differences $p<.001$), regardless of race or gender. In the Fall Faculty Retreat, we discussed climate survey feedback with the faculty. We will implement the climate survey again this year towards a path of sustainably integrating it into the School's assessment practices. However, we will need to identify an "owner" of this process after the grant terminates. Our ability to do that will align with the value the community sees in collecting these data.

Alternating Leads Co-Teaching Model

The third example is the pilot implementation of an alternating leads co-teaching model. Collaborative teaching models are rare in higher education (Bacharach, Heck, & Dahlberg, 2007; Cook & Friend, 1995). However, development and improvement of innovative activities are a critical aspect of course delivery that can advance student-centered and socially just learning goals. Yet, faculty are provided little time to innovate and are not appropriately evaluated or rewarded for it. In the Alternating Leads model, two faculty share a course assignment with one orienting towards that year's delivery and the other taking responsibility for curricular innovation and vertical integration of key skills with other courses. This structure is intended to institutionalize innovation and address issues of teaching practice as a core instructional activity rather than work supported by external funds, by providing faculty with time and support for ongoing, progressive course development. It facilitates an ongoing vertical integration initiative focusing on developing skills like writing, working in teams, using computational tools, and statistical analysis throughout the program curriculum. It also frees up faculty time for more interactions with students by being more efficient with logistical, technology, and delivery processes. Finally, with this structure, instructors can model the collaborative and inclusive teaming behaviors we seek to develop in students.

The Alternating Leads model was developed over one year's work in the curriculum committee then presented in a faculty meeting and approved by faculty in the next meeting. While the faculty who have opted into this model are enthusiastic, there is resistance from administrators who have difficulty reconciling the workloads of the alternative leads with the more traditional sequestered model of instruction. There are also faculty who do not choose to participate. We piloted implementation of the Alternating Leads structure with 15 faculty in eight courses (six studio courses and two lab courses) over four academic quarters (Fall 2018 – Fall 2019). Within the basic structure described above, individual pairs have autonomy to work out detail as appropriate for their course and teaching practices. To assess how the Alternating Leads model is working, we are conducting interviews with each faculty member participating in Alternating Leads as well as relevant administrators.

Though data collection is still in progress, initial analysis of six interviews conducted to date (with five faculty instructors and one administrator) indicate that co-teaching has the potential to support faculty in improving curricular materials, instruction, and student learning and experiences. Instructors cited several benefits of co-teaching, particularly using the Alternating Leads model, including: freeing time for course development and professional reflection; utilizing both instructors' expertise in the development of the course and resolution of implementation challenges; allowing instructors time to travel for conferences, engage in other professional development activities, or address illness or other personal/family needs as needed without course disruption; mentoring new faculty (through pairings between new and more experienced instructors); and modeling professional collaboration for students.

The instructors and administrator also raised challenges related to co-teaching. For example, an administrator raised concerns about the difficulty of assessing co-teaching in pairs, particularly given that there are many different models currently used in the department. Some co-teaching pairs teach different course sections in parallel, some divide responsibilities such that one instructor delivers lectures and the other leads studio or lab activities, and some share lecture and studios or labs (if applicable) and alternate lead delivery of content either weekly or by theme. Instructors also had different models for course development while co-teaching. Several instructors shared concerns about whether co-teaching is recognized appropriately by administrators, particularly for review, tenure, and promotion. The administrator indicated that in order to support Alternating Leads, the department and its members should develop a shared vision and shared values around co-teaching.

In summary, faculty participants find value in re-situating instruction from an individual activity to a collaborative one, but it requires administrative evaluation and oversight that do not coincide with current norms and practices.

Community Building, Problem Solving First Year Elective

The fourth example is the implementation of an innovative elective course, *Engineering Problem Solving Fundamentals*, early in students' university experience. During Winter 2018, the CBEE Curriculum Committee discussed issues with the current first year offering in Computations. Issues of student retention and course instructional stability were raised. A core problem was the unequal preparation of students for the computational class. In short, some students would fly through an activity while others struggled slowly through it. This variation has led to several issues in activity design and course management. The Curriculum Committee discussed a new model to address 1st year computation. It would place an intermediate course as an engineering elective between the orientation course and the required computations course. Historically, engineering electives have been reserved for upper-division technical electives with the intent of adding technical breadth building on the fundamentals that a student has already learned. By making Engineering Problem Solving an elective, those students who have not had opportunity to develop computational and problem solving skills can develop those skills without extra cost or credits. We hypothesize that many students currently have limited engagement since they lack skills and self-efficacy in computation (e.g., see Hutchison et al., 2006). This leads to temptations for unproductive (social loafing) and unethical (copying) behaviors. The goal of this first year elective, is to invest one of the elective courses up front to those who need it. Such investment will shift to more engaged participation.

This course was approved by representatives of all three programs and then brought to the Associate School Head who asked about transfer students and typical student spring course load, since the required computations course was moved from winter to spring. This proposal was then discussed at a faculty meeting with general support from the faculty to move forward with this proposal. Following this discussion an *ad hoc* committee of CBEECC members and CBEE faculty with interests in computation and computational thinking convened to flesh out these ideas and submit an official course proposal. The *ad hoc* committee developed recommendations on the proposed course, including learning outcomes and a draft syllabus. This course aligns with RED goals by focusing on helping students engage authentic engineering practices and building inclusive communities.

Engineering Problem Solving Fundamentals is designed to help students develop skills and habits that will benefit them throughout their college and engineering careers. By focusing on broader habits of mind (systems thinking, algorithmic thinking, metacognition, perspective-taking) and foundational skills (diagramming, dimensional analysis, empathetic communication) the course aims to build connections for students between their day-to-day "studenting" and their planned or aspirational work as engineers. This shift aligns with the overall goal of the RED project.

The course covers four complex systems and walks students through the process of understanding and modeling each system. In the first three weeks students study themselves as learners in the complex system of their lives and educations. Specific content is drawn from engineering education, cognitive science, social justice, psychology and broader educational research and is primarily delivered to students through readings, mini-lectures and large group discussions. The next three systems to be studied are all engineered systems relevant to the three programs in CBEE (e.g. water and wastewater conveyance and treatment, or a pharmaceutical production facility). As the students learn and study the engineered systems, the course delivery modes develop to remove scaffolding so that, ideally, by the final system being studied students are largely motivating and implementing their own strategies and skills based on the more explicit examples of the previous weeks in the course. Through the course the instructor becomes less central to the students' learning of the content, and is therefore more able to coach and guide them in choosing strategies and practicing habits and skills.

As an example, for the first 2-hour studio where students are learning about a new engineered system, they are given explicit instructions to first individually draw or write their current understanding of that system – no matter how little they think they know. Students are then guided in teams of three – each student with a specific role – to share their individual models and create an improved model as a group. They are asked to write a brief reflection on this process (referencing course content about systems thinking as well as teamwork and group dynamics). The instructor then asks them to share their models with other groups and give and receive feedback, which is followed by another brief reflection asking students to compare the feedback they gave and received and how it influenced their next choices. Back in their groups of three, students create a prioritized list of questions they need answered to improve their understandings (there is a "no googling" request during this activity, and students are asked to instead record their questions as they occur). The instructor then gives a mini-lecture response to the group's top questions. Students create another draft of their model and submit all drafts, reflections and notes for feedback. Finally, in the next class meeting, students are encouraged to use all their resources to investigate the system and compare their new understanding to their model. The instructor leads a large-group discussion about sources of information asking students to contrast what they learned from each other, from the instructor and from their other resources. By the end of these three hours students have a rough mental model of a complex engineered system, but they also have a bank of shared experiences as learners and thinkers that can be referenced throughout the course. Students are introduced to this multi-layered learning approach as three levels: a "doing" level that consists of the conscious actions they will take to complete an assignment (e.g. "talking, drawing, calculating"); a "thinking" level consisting of the content they will be focusing on (e.g. "where does my drinking water come from, and where does my wastewater go?"; and a "meta" level consisting of the thinking and learning strategies being taught in the course (e.g. "how do I get started on this? Who is a reliable source of information? What strategies have we learned to reduce my discomfort in not knowing this already?").

Forty students are enrolled in the initial offering of the course in Winter 2020. The instructor reported positively to the Curriculum Committee. However, after this course was planned, the college itself announced plans to completely restructure the first year, eliminating unit affiliations and have all students be general pre-engineering majors. While the course developed through the RED project fits within the goals of the college initiative (greater persistence and graduation rates), there is a rather traditional perspective on the college group exploring this initiative and it is unclear how much of the innovative CBEE practices will be taken up.

Position Descriptions

Finally, we discuss our efforts to meaningfully allow faculty to have tailored Position Descriptions that align with their professional activity. As described previously (Sweeney et al., 2017), an early, targeted activity of our RED project was to revise the School's approbations and reward structure so that those in the CBEE community who engaged in transformative work would be appropriately recognized. Position Descriptions represent a clear opportunity in our efforts to empower faculty and staff to identify, agree upon, and carry out responsibilities that can be outside of the traditional norms in the academy such as identifying Change Leaders and formally allot 10% of their effort toward shifting the School's culture to re-situate learning and instruction. However, the meaningful incorporation of new Position Descriptions into faculty annual review has not gained traction. In particular, we envisioned all employees altering their position descriptions (PDs) to reflect a formal expectation to promote achievement of college and university goals in relation to constructing a more inclusive and collaborative community. Building upon the changes to the PDs, we envisioned a shift in the annual performance review process as well, such that the review would include transformative work along with that of other more traditional categorical areas (e.g., research and teaching). In brief, faculty and staff would reflect on the previous year's accomplishment along categorical areas highlighted in their PDs and look forward to expected efforts in the upcoming year. The evaluations would include a short meeting with the School Head to discuss successes, and to generate strategic paths around barriers to success. In these ways, we envisioned the transformative work of RED would be expected, reviewed, and recognized.

While our initial School leadership and that in the College of Engineering formally supported the proposed changes to practices surrounding performance expectations and evaluation (Bothwell, et al., 2018), the actual implementation of the new practices were not altogether successful. Reflections as to why this was the case point to the lack of engagement and initiative on the part of the School's leadership, as the School Head plays the primary and central role in employee performance evaluation. During the course of the RED project, our School has had four different people serve as School Head, and this high level of transition has been problematic in and of itself. Other characteristics and circumstances unique to each individual occupying the Head position also contributed to the inconsistent uptake of the new practices. For example, the majority of the leaders authentically valued transformative work around teaching practices and toward cultivating socially just classrooms and workplace, but in a minority of instances a more traditional academic value structure that privileges research activity existed. When the leader's values aligned with the more traditional structure, there seemed to be less incentive to shift practice. In a couple instances, the Head served in an interim or acting position, thus making changes to performance review practices more difficult, especially when the Acting Head was not at the rank of Professor. Finally, we noted that when a leader was uncomfortable with situations where conflict was involved, the Head would avoid challenging structural barriers and shifting practices towards those that were more socially just.

Summary

In this paper, we present a reflection on the potential for and barriers to sustainability of five initiatives within the greater activity in our larger organizational change project. These initiatives all intend to re-situate the School towards a culture of inclusivity and realistic, consequential work. The degree that they have the potential for long-term sustainability very much depends on the way they fit within the School's current activity system that they seek to shift. For example, the use of LAs aligned very much with current norms and practices and appears likely to be taken up with fidelity, even as it drastically shifts the role of undergraduates in instruction. In contrast, the effort towards individualized Position Descriptions conflicted with circumstances and School norms and did not meaningfully get taken up. The use of the climate survey instruments, the Alternative Leads co-teaching model, and the innovative elective in problem solving are somewhere between these two asymptotes. In all cases, the interactions with the cultural elements of the larger activity system critically determined aspects of broader support and resistance.

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