Board 31: Engineering with Engineers: Revolutionizing a Mechanical Engineering Department through Industry Immersion and a Focus on Identity

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Engineering with Engineers: Revolutionizing a Mechanical Engineering Department through Industry Immersion and a Focus on Identity

Abstract

The Mechanical Engineering Department at Seattle University was awarded a grant by the National Science Foundation (NSF) Revolutionizing Engineering and Computer Science Departments (RED) program in July 2017. This award supports the development of a mechanical engineering program where students and faculty are immersed in a culture of doing engineering with industry engineers that in turn fosters an identity of being an engineer. Cultivating a culture of doing engineering can result in graduates who not only are prepared technically and professionally with a practical, realistic understanding of what it is to be an engineer, but also who identify with and are committed to the engineering profession. This culture of doing engineering is created through changes in four essential areas indicated by research: a shared department vision, faculty, curriculum, and supportive policies. Unifying these changes is a significant connection to industry. This paper reviews the initial process of developing this culture of "Engineering with Engineers" and shares progress in the four essential areas needed to develop a culture of doing engineering. It also provides insights on lessons learned.

Introduction

In 2017, the Mechanical Engineering Department at Seattle University was awarded a National Science Foundation grant to revolutionize the department. The department's proposal centers on creating a program where students can develop a strong identity with their chosen profession. The project leverages the department's small size and close ties with industry to create a culture of "Engineering with Engineers." The first two sections of this paper provide an overview of the project. This overview is taken from the NSF Grantees Poster paper presented at the 2018 ASEE Annual Conference [1]. The Project Description section describes the four areas of change [1] and describes goals and progress to date in each of the four areas. The remaining sections discuss ongoing evaluation and research and long-term goals.

Background

Identity influences who people think they are, what they think they can do and be, and where and with whom they think they belong [2] - [5]. People's identity shapes the experiences they embrace, and reciprocally, those experiences shape their identities [6] - [8]. People behave consistently with their identities [9], [10], choosing behaviors with meanings that match their self-conceptions [11], [12]. When people identify with an esteemed group, they feel better about themselves and, in turn, they feel better about the group [13], [14]. If people strongly identify with a group, they are steadfast, defending the group, staying in the group, and supporting the group [15].

In academic settings, identity influences whether people feel they belong in a program and what they believe they can achieve. It has been shown to influence what goals are pursued and the level and type of effort put towards those goals [10]. Research also shows that identity and fit are important factors affecting persistence in STEM fields [6]. When people perceive a fit between themselves and their fields, they persist longer in those fields [16] - [18]. Hence, identity is a determining factor in one pursuing, persisting, and persevering in engineering [10], [19].

The development of identity is a social process. People's thoughts and behaviors are shaped through relationships and reflected appraisals with others [3], [15], [20]. Identities are further derived through associations, affiliations, and identifications with groups [16], [21]. Tonso [22] observes that identity development is an enculturated process where identities are acquired through "community-based interactions" and Beam et al. [19] concur that social contexts affect identity. In engineering education, situated learning is central to identity development [22]. Therefore, this social process of identity development can be realized through the culture of an engineering program.

Objective

The goal of this project is to develop a mechanical engineering program where students and faculty are immersed in a culture of doing engineering with industry engineers that in turn cultivates students' engineering identities. The culture of a program plays a significant role in effective, innovative STEM education [23], [24]. The culture of "Engineering with Engineers" is being built through the interactions of students, faculty, and industry, through participation in engineering-related activities, and through reinforcement of shared similarities. We are studying how this new culture affects the identities of students and faculty, and how these enriched identities affect students' engagement in and commitment to engineering.

Project Description

Creating this new culture of "Engineering with Engineers" requires change in two ways. First, culture is shaped, in part, by the identities of those in the culture. It is negotiated, co-created and reinforced through communication and social interactions [25]. It develops organically from the behaviors of a group through association and shared experiences [26]. Thus, a variety of actions are being implemented to support these types of shared experiences. Second, culture in an educational setting is influenced by the priorities of the institution or department. Thus, a number of changes to the structure and priorities of the program are being pursued.

These changes are being implemented following best practices identified by Henderson et al. [27]. These include having coordinated efforts applied over extended periods of time, providing regular feedback and opportunities for reflection, changing faculty conceptions (e.g., their identities), providing incentives for change, and enacting policy changes from the ground up.

The changes are organized within the four-square typology of change proposed by Henderson, Beach, and Finkelstein [27]. This theory, based on an extensive review of articles on facilitating change in STEM education, identifies four areas of change: shared vision, reflective faculty,

relevant curriculum and pedagogy, and supportive policies. Each of these change areas is summarized in the following paragraphs.

Shared Vision: Building a Culture that Cultivates Identities as Engineers

Goal:
Through interaction and discussion, the faculty will establish a culture of "Engineering with Engineers." The goal is for the mechanical engineering department to be a hub of engineering activity where faculty, students, and industry can share experiences and ideas. Additionally, the department will forge relationships with key professional societies and use those relationships to form ties with local industries.

Current status:
a. Obtaining consensus on the shared vision. At the beginning of this project, significant efforts were devoted to obtaining the shared department vision. As a small department with only seven full-time faculty, the goal is that all faculty are involved in this project and contribute to the creation this culture change. The focus on improving undergraduate education united the faculty, who were willing to openly discuss approaches that could best benefit students.

The process of adopting a shared vision started by holding lunch meetings where all faculty brainstormed how they envision "Engineering with Engineering." These brainstorming sessions led to planning sessions surrounding curricular change discussed in the *Curriculum* section below. The "critical doing" of developing the new curriculum allowed the faculty to examine the current system, identify issues to be addressed, and build the shared vision.

Faculty reached the consensus on bringing industry practice to our students and sharing the vision of "Engineering with Engineers" during the first year of this project.

b. Revised department mission. A department vision day was held for faculty to discuss and update the department mission. Discussions were facilitated by one of the PIs, who is not the faculty of the department, using a three-step process:
1. Questioning/addressing the usefulness of a mission statement
2. Generating information to support revising the mission statement
3. Revising the mission statement

Questioning the usefulness of a mission statement allowed the faculty to voice concerns and critiques about the existing mission statement. This led to a consensus on the uses of a mission statement. "Who uses the mission statement to do what?" was the guiding question for all faculty to start envisioning what the revised mission statement should be. Faculty then identified issues with the current mission statement and three aspects that should be included in the revised mission statement. The new aspects were *pride, distinctiveness, and engineering with engineers.* These aspects provided direction for faculty to revise the mission statement. Faculty then addressed a set of questions for each aspect:

- Pride
  - What is an aspect of your work in the department about which you are proud?
  - What is something about the department in general about which you are proud?
- Distinctiveness
  - In what ways is the Seattle University Mechanical Engineering department like other ME departments?
  - In what ways is the Seattle University Mechanical Engineering department distinctive?
- Doing Engineering with Engineers- focus of the RED project
  - How are you already embodying the RED grant focus of doing engineering with engineers in your work?

Through the discussion of these questions, faculty worked together and revised the mission statement as the following:

"The mission of the mechanical engineering program at Seattle University is to provide educational opportunities for students seeking to enter the mechanical engineering profession, so that they can achieve competence in the field while recognizing their social responsibilities. The program provides a strong foundation in the areas of mathematics, basic sciences, engineering theory and practice, and the humanities and social sciences. It encourages further self-development and life-long intellectual achievement through personal reflection. Additionally, the program seeks to build student skills in written and oral communication, socially, economically and environmentally responsible decision making, and professionalism."

Reflective Faculty: Strengthening Interaction with Industry

Goal:
To strengthen faculty's connection to industry and aid their ability to facilitate student connections, faculty will participate in an industry immersion experience during the summer where they will work with practicing engineers and learn about current industry practices. In addition, faculty will acquire relevant industrial and teacher training. Ultimately, faculty will see their role, or identity, as guides moving students towards becoming practicing engineers. Students, too, will reflect on their identities as engineers and how those relate to their education and career paths. To bring industry to campus, an Industry Adviser with extensive experience in industry and passion for engineering education, will be on campus part-time and provide insights to faculty and students on how to bridge course work and industry practices.

Current status:
a. <u>Faculty industry immersion experience.</u> The grant provides opportunities for faculty to be part of a summer industry immersion experience. In summer 2018, one faculty member spent a month working in a local company. Through a self-documenting process, the faculty member shared what he learned about industry, about industrial processes, etc. with the rest of the faculty before the new academic year. They took questions and the faculty took inspiration and identified educational connections.

b. Faculty educational training. To ensure faculty possess tools to bringing more authentic problems to their classroom, Prof. Michael Prince led a workshop on problem-based learning. All but one faculty members were able to attend the workshop. During the workshop, faculty identified new ways to integrate real problem solving into one of their courses.

c. Industry Adviser. The hired industry adviser has extensive experience in industry and is passionate about sharing his experience with students. He is available on campus one day a week. Example functions and responsibilities of the industry adviser include:

- strengthening the connection among the department, its students, and industry.
- providing students with mentoring and career advice and industry-relevant experiences.
- assisting faculty in building a culture and environment of "doing engineering."
- helping faculty identify industry immersion experiences.
- helping faculty connect theory to practice in curriculum revision.
- helping plan yearly Makeathons.
- helping find co-ops and/or internships for students.
- arranging events to connect faculty and students with industry.

Relevant Curriculum and Pedagogy: Maintaining Strong Connections with Industry and Incorporating Industry Practice into the Program

Goal:
Across the mechanical engineering curriculum, there will be connections to industry and student engagement in activities that reflect what a practicing engineer might do. Such connections and activities require pedagogic changes to existing courses as well as the implementation of a new sequence of vertically integrated courses with strong industrial components. In these new courses, teams consisting of freshmen, sophomores and juniors will work on engineering projects. These projects will be advised by practicing engineers and faculty members and emphasize experiential learning. In addition to curriculum changes, the department encourages and sponsors regular seminars, field trips, social events, and Makeathons to connect the program to industry and industry to the program.

Current status:
a. Course development and curriculum revision. To implement the vision of "engineering with engineers," faculty examined the current curriculum and identified several ways to strengthen the curriculum and integrate our goal of "engineering with engineers." The process of "critical doing" actively involved faculty and students in the design of the new curriculum.

First, faculty reviewed elements in the current curriculum that effectively connect students with practicing engineers. The program currently has a strong senior design course sequence where seniors work in teams on real projects sponsored by industry for an entire academic year. This provides a valuable experience of doing hands-on engineering projects with practicing engineers. However, this experience is missing from the first three years. Hence, faculty proposed a separate design course sequence, where freshmen, sophomores and juniors can have similar

experience and work on authentic design projects with mentorship from practicing engineers. Furthermore, having a team that consists of freshmen, sophomores, and juniors working on the same project naturally fosters the community feeling and enhances the sense of belonging. This "vertically integrated design" (VID) course sequence became the center of the curriculum reform.

Although the consensus of adding the VID course sequence was reached, it was difficult to get all faculty to agree on the specifics of the new curriculum and how current courses would be revised to free credits for the new VID courses. The department addressed this gridlock by involving seniors in the process. During the winter quarter, seniors worked in groups to evaluate how well proposed curriculum changes (from various faculty and anonymized) met the goal of "engineering with engineers." Seniors were one quarter into their senior design projects so had some perspective on the value of the senior design and working with industry. They discussed the proposals and provided feedback on the modifications needed to enhance "engineering with engineers." A staff member compiled students' feedback and a faculty member from outside the department thematically grouped students' feedback into the essential features needed in the VID courses. Faculty listened to these suggestions from students and revised the curriculum to align with the shared vision. The resulting proposed curriculum is currently in the process of seeking approval from the university and is planned to be rolled out in Fall 2019.

b. Industry seminars and socials. Speakers from various companies including Cepheid, Microsoft, K2 Sports, Kenworth Truck Company, Puget Sound Transportation, and Boeing were on campus to share their experiences. Students and alumni were encouraged to attend receptions after each seminar to mingle and connect with others to build a community and extend their network.

Field trips to local companies, such as 3D Systems, brought students to industry to observe and learn from practicing engineers. Several students also gained internship opportunities through these interactions with industry.

c. Update and use makerspace. The student-centered makerspace was updated with several new 3D printers and additional tools. Students are encouraged to use the makerspace for various projects. A departmental Makeathon is in planning to bring students and industry volunteers together to solve a design problem and enhance hands-on experiences.

Supportive Policies: Changing Expectations in Departmental Reviews

Goal:
To incentivize and motivate faculty, performance reviews will recognize and commend faculty's engagement with industry and curricular revision. Department assessment guidelines and procedures will also reflect a broader view of student assessment.

It is important to note that a culture takes time to grow organically and changes cannot be forced. Building a shared vision warrants a solid foundation for the project. Curriculum updates and activities that bring faculty, students and industry together enhance the community-based interactions and, in turn, cultivate the culture of doing engineering. Supportive policy plays a role in motivating and sustaining changes.

Current status.
A number of changes to the structure and priorities of the program have been proposed. The work done to enhance industry connections and efforts to enhance engineering with engineers were considered in the department faculty's annual performance reviews. Policies on tenure and promotion standards are being discussed at the university level through the ADVANCE program sponsored by NSF [28]. Conversations with the Provost to gain more awareness of the project and more support for the changes are ongoing.

Evaluation and research

Goal:
During this project, changes to the program and to student and faculty identities will be evaluated through interviews, surveys, portfolios, reflections, and audio and/or video documentaries. All students and faculty in the program will be invited to participate in these evaluation activities and responses will be tracked every year to document the changes.

The three main research questions this project aims to study are:
- How have the identities of the students and faculty changed?
- How has the departmental culture changed?
- What happened in response to the changes made and the changes that occurred?

Current status:
Baseline explicit identity surveys for existing mechanical engineering students were conducted and results presented in the 2018 ASEE annual conference [29]. Additional baseline engineering and gender identity data were collected via Implicit Association Tests (IATs) and results will be presented in the 2019 ASEE annual conference [30]. Both explicit identity surveys and IATs are continuing and results will be analyzed and presented in future conferences. In addition to student surveys, selected portfolios were collected from current students to gain insights on students' knowledge on portfolio construction and help set goals on future portfolio activities.

An external evaluation team is monitoring the process and progress of culture change in the department by interviewing faculty and students in the department. The change process is also being documented via audios and videos of faculty interviews.

Long-Term Goals

A focus on identity encourages reflection and a larger discussion about how students see themselves, their education, and their profession, and how these views uniquely affect

underrepresented or marginalized students. A culture of "engineering with engineers" could result in graduates who not only are prepared technically and professionally with a practical, realistic understanding of what it is to be an engineer, but who also identify with and are committed to the engineering profession. Researchers have suggested the culture influence is especially important for women to persist in a field [22], [29]. Hence, results of the study are hoped to lead to a clearer understanding of the changes that promote engineering identities, particularly in women, and how such identities affect students' sense of belonging in a program and their persistence in the major.

This study will also lead to a better understanding of the factors that influence faculty identity, and how these richer identities affect how they view their roles and their students. It is our hope that this project will enact changes in incentives and training that promote industry engagement and build strong industry-education connections and that this conversation about engineering identity can lead to a better understanding of how best to create an inclusive educational system.

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