Cultivating a Culture to Foster Engineering Identity

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Bio

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Introduction

The Mechanical Engineering Department at Seattle University was awarded the National Science Foundation (NSF) Revolutionizing Engineering and Computer Science Departments (RED) grant in July 2017 to support the development of a program that fosters students' engineering identities in a culture of doing engineering with industry engineers. The Department is cultivating this culture of "Engineering with Engineers" through changes in four essential areas: *a shared department vision, faculty, curriculum, and supportive policies* [1] - [4].

This paper reports the continuous efforts of our RED project and updates previous NSF Grantees Poster papers presented at the 2018, 2019, 2020 and 2021 ASEE Annual Conferences. The project background and objective are unchanged; hence, the first two sections of the paper are taken from our previous papers [1] - [4]. The project description section summarizes the changes made in the four essential areas thus far and provides important updates in each of the four areas with emphases on actions taken during the previous year. The remaining sections of this paper discuss ongoing evaluation, research, and plans related to disseminating results of our project.

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 [5] - [8]. People's identity shapes the experiences they embrace, and reciprocally, those experiences shape their identities [9] - [11]. People behave consistently with their identities [12], [13], choosing behaviors with meanings that match their self-conceptions [14], [15]. When people identify with an esteemed group, they feel better about themselves and, in turn, feel better about the group [16], [17]. If people strongly identify with a group, they are steadfast, defending the group, staying in the group, and supporting the group [18].

In education, identity influences whether people feel they belong in a program and what they believe they can achieve. Identity has been shown to influence what goals are pursued and the level and type of effort put towards those goals [13]. Research also shows that identity and fit are important factors affecting persistence in STEM fields [9]. When people perceive a fit between themselves and their fields, they persist longer in those fields [19] - [21]. Hence, identity is a determining factor in one pursuing, persisting, and persevering in engineering [12], [22].

The development of identity is a social process. People's thoughts and behaviors are shaped through relationships and reflected appraisals with others [6], [18], [23]. Identities are further derived through associations, affiliations, and identifications with groups [19], [24]. Tonso [25] observes that identity development is an encultured process where identities are acquired through "community-based interactions" and Beam et al. [22] concur that social contexts affect identity. In engineering education, situated learning is central to identity development [25]. Therefore, this social process of identity development can be realized through the culture of an engineering program. 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.

Objective

The project's objective is to develop a mechanical engineering program where students and faculty are immersed in a culture of doing engineering with practicing engineers from industry that in turn fosters students' engineering identities. The culture of a program plays a significant role in effective, innovative STEM education [26], [27]. The culture of "Engineering with Engineers" is built through the interactions of students, faculty, and industry, through participation in engineering-related activities, and through reinforcement of shared similarities. The objective of our project is to study 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

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 [28]. It develops organically from the behaviors of a group through association and shared experiences [29]. It is also important to know that culture in an educational setting is influenced by the priorities of the institution and department. We have been creating this new culture of "Engineering with Engineers" through a variety of actions that support these types of shared experiences to cultivate this new culture. To organize the actions and changes needed for this new culture, we follow the best practices recommended by Henderson et al. [30]. From an extensive review of articles on facilitating change in STEM education, Henderson et al. indicated four areas of change: *shared vision, reflective faculty, relevant curriculum and pedagogy, and supportive policies*.

In the following sections, we summarize actions we have taken in these four areas thus far to promote changes and cultivate this new culture. Although the COVID-19 pandemic brought unprecedented challenge to our work, it also presented opportunities for us to take different approaches in order to reach the same goals. We also share those specific approaches in detail and reflect on their impact to our project.

Shared Vision: Building a Culture that Cultivates Identities as Engineers

Goal:
A shared vision is an important foundation for a culture. As a small department with nine full-time faculty, involving all faculty in this project was essential to successful culture change. At the beginning of this project, through in-depth discussion, the faculty decided to establish a departmental culture of "Engineering with Engineers" to foster engineering identity. Collectively, the faculty work to make the Mechanical Engineering Department a hub of engineering activity where faculty, students, and industry can share experiences and ideas [2]. Even during the pandemic, this shared vision continued to guide many community building activities for the Department.

Status:

a. <u>Sustained a shared vision.</u> A shared vision is an important foundation for a culture. Establishing a shared vision was the first accomplishment of this project. The focus on improving undergraduate education united the faculty, who were willing to openly discuss approaches that could best benefit students. Together, a shared vision was established to reflect the goal of building a culture in the Department to foster engineering identity. Details on the process the Department used to establish this shared vision can be found in Ref. [2].

This shared vision guides all the activities described in the following sections.

b. <u>Established the department mission.</u> Once a shared vision was established, the faculty examined the usefulness of the Department's previous mission statement. Faculty then identified issues with the previous mission statement and agreed on three aspects to include in a revised mission statement. The new aspects were *pride, distinctiveness, and engineering with engineers.* These aspects provided direction for faculty to revise the mission statement.

A Department vision day was held for faculty to discuss and update the Department mission. Together the Department updated our mission statement as follows:

> *[The mission of the SU Mechanical Engineering Department is to] Provide a technically rigorous design-focused education in a collaborative environment that emphasizes individual attention and connections to industry, while preparing students to help create a more just and humane world.*

This new mission statement helped the Department sustain our shared vision and underlined important aspects of our work. Details on how the department worked together to update our mission statement can be found in Ref. [2].

c. <u>Confronted issues related to inclusion.</u> While we worked on building the new culture, we paid special attention to issues that blocked change. Earlier reports from our external evaluators, Inverness Research, revealed instances in which students did not feel included in some settings within the Department. Feeling a sense of belonging to mechanical engineering is essential to build and strengthen students' engineering identities. From the situations identified in these reports, faculty sensed a strong need to raise the awareness of diversity, equity and inclusion (DEI).

Over the years, faculty and staff members have participated in numerous trainings and discussions on DEI-related issues and practices. One concrete outcome was the development and adoption of a diversity and inclusion syllabus statement. This statement has been circulated in the College and the University, and it was adopted by faculty from other Departments and Colleges.

Our complete diversity and inclusion syllabus statement can be found in Ref. [4]

d. <u>Implemented a revised student advising procedure.</u> In our department, each student meets with their assigned faculty advisor three times a year (each term). These meetings and

relationships between the student and their faculty advisor are key to the new culture and to students' perceptions of themselves as engineers. They are also essential for students to sense the deep care from the faculty and to feel that they belong to the program.

During the second phase of the project, faculty discussed and agreed upon an advising process, manifested in a checklist, that would promote connections between students' and the program's goals. The uniform advising procedure, specifically during the pandemic, ensured students were cared for consistently across the department. Details of the advising process and the checklist can be found in Ref. [3].

e. Established ME Student Advisory Council. The Student Advisory Council was established to create a channel to directly communicate with our students. The Council meets with the Department Chair twice per quarter and provides feedback and recommendations on topics brought forward by both students and faculty. With such information, the Department can address concerns and responsively direct culture change in the four areas. During the pandemic, it was especially important to receive input on department actions and to show care for our students.

f. Supported student/alumni mentors. Continuing to foster the community during the pandemic was an important but difficult task. Supporting student group activities was important to keep the community connected. The Department hired tutors and peer mentors who held study halls and helped other students. The Department also encouraged recent alumni to mentor graduating seniors, and seniors to mentor other students via various channels such as Discord, LinkedIn, and professional societies.

g. Connecting the department by holding retreats and "Teaming" exercises. At the beginning of each academic year, the RED PI team organizes a retreat for department's faculty and staff to collectively review progress made and plan actions for the coming year. These retreats serve an important role in connecting faculty and staff in the department and centering our focus.

During the latest retreat, we reflected on the year of remote working and discussed ways to navigate back to in-person teaching and learning. One important theme that emerged was that we acknowledged our support of one another and the impact of our work as a team. We decided to hold a "Teaming" exercise every three weeks as an avenue to converse, connect, and continue to grow as a team. "Teaming" utilizes one of the 60-minute time slots originally set aside for department meetings and focuses on faculty and staff sharing knowledge and experiences. In addition to connecting the team, "Teaming" has the potential to contribute to an inclusive environment and to serve as a mechanism to sustain culture change. More details on "Teaming" will be shared at this year's ASEE conference [31].

Reflective Faculty: Strengthening Interaction with Industry & Understanding Diversity and Inclusivity

Goal:
Faculty who have strong connections to industry and an understanding of diversity and inclusion are better able to guide the formation of students' engineering identity and move students

towards becoming practicing engineers who create a "more just and humane world." Faculty also need to grow and continue to reflect in order to sustain culture change. We are taking several steps to promote the growth of faculty and faculty reflection.

Status:

a. Faculty industry immersion. The RED grant provides a unique opportunity for faculty to spend one summer month in industry [1] - [3]. Thus far, two faculty members have participated in the summer industry immersion program, which broadened faculty views and strengthened their ties to industry. They also brought feedback from industry on how to update our curriculum and integrate course content with current industry practice. Details of their experiences can be found in Ref. [2] & [3]. Although the pandemic continues to hinder the faculty industry immersion program, we are in talks with local industry partners regarding future industry immersion opportunities.

b. Faculty training. Faculty have been attending training courses hosted by various organizations on different subjects since the beginning of the project. For example, over the past years, the Center of Faculty Development and the College of Science and Engineering Project Center at Seattle University have led training sessions on topics related to inclusive pedagogy, building relationship-rich classroom experiences, and combating implicit bias. During the pandemic, the Center for Digital Leaning and Innovation at Seattle University provided training for faculty to effectively move our courses online. Some faculty also attended workshops and seminars hosted by professional societies such as ASME (American Society of Mechanical Engineers) and AAC&U (American Association of Colleges and Universities) to expand their toolkit in mediating DEI issues, increasing classroom engagement, changing in higher education, and building closer relationships with industry. Although the pandemic forced almost all training courses online, it did lower the barrier for faculty to attend such events.

c. Industry Advisor. To bridge the classroom and industry, an Industry Advisor with extensive experience in industry and passion for engineering education was hired to join the program at the beginning of the project. Ever since the position was established, students have been seeking advice from the Industry Advisor in many ways [1] - [4]. Pre-pandemic, the Industry Advisor was on campus one day a week. During the pandemic, the Industry Advisor remained available, albeit online. The Industry Advisor is transitioning to be back on campus regularly this year while continuing to hold online meetings with students and faculty.

d. Remote teaching and learning. The pandemic gave faculty an opportunity to change how we design and deliver our courses. To promote inclusive practice, faculty utilized recorded lectures, online collaboration tools and instant messaging apps to provide multiple ways of communication for students. To continue the emphasis of "doing engineering," faculty also implemented remote laboratories that utilized tools accessible to students. More details on changes made to accommodate remote teaching and learning can be found in Ref. [32].

e. Connecting with industry. It may seem surprising, but we found interactions with industry easier in the virtual world. In many settings, we were able to invite practicing engineers from all over the country to join classes online. Industry partners mentored students in design projects, gave guest lectures, or simply participated in social events to connect with students and faculty.

Recent graduates also connected with graduating seniors to provide career mentorship in a less formal setting via social media like LinkedIn.

f. Care for students. The pandemic prompted faculty to reflect on the importance of caring for our students. During the pandemic, faculty broadened how they interact and engage with students. They utilized online communication tools such as Zoom and Microsoft (MS) Teams to host their office hours, advise and mentor students, or have one-on-one conversations with students in need. Many students felt comfortable sending direct messages to a faculty member via MS Teams and most faculty responded to those messages in a timely matter – something students deeply appreciated. Showing care for students is especially important during pandemic when not only students' learning is impacted but also their mental and physical health. A culture of care contributes to a culture of belonging.

g. Collaborative spirit. Collaboration among faculty and staff highlights the inclusive culture in the department. Throughout the new curriculum described in the next section, there are many opportunities for faculty to co-teach or collaborate on a course. Over the past two years of implementing this new curriculum, we learned that such a collective mindset helped the department work together toward the same goals. It also is important to note that collaborations occurred among faculty and staff (e.g., lab assignments and event coordinating). Faculty and students all recognized and appreciated the effort our staff put into the program and its people.

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

Goal:
The goal of the new Mechanical Engineering curriculum is to maintain close connections to industry and have students engage in activities that reflect what practicing engineers do across the curriculum. Such connections and activities require pedagogic changes to existing courses as well as implementing a series of new courses with components related to industry practice. In addition, extracurricular activities such as seminars, socials, design challenges, and club activities also connect students with engineering practice. These guiding principles for the curriculum remained in place and effective during the pandemic.

Status:
a. Revised the ME curriculum. The Department's shared vision of "Engineering with Engineers" guided the curriculum revision. Revamping the curriculum was also an important process to cement the department's shared vision. See details of the new curriculum and its development in Refs. [2] & [3]. The key elements of the new curriculum include 1. Vertically integrated design project courses (VIDP) and 2. Integrated Electrical Engineering and Data Acquisition (DAQ) courses.

1. Vertically integrated design project courses (VIDP). Our ME program traditionally has a strong senior design course sequence where seniors work for an entire academic year in teams on real projects sponsored and mentored by industry. Real industry design experience, however, was missing in the first three years of the program. Hence, a separate design course sequence, where first-, second-, and third-year students come together each spring to work on design

projects mentored by practicing engineers, was added to the curriculum. In this new VIDP sequence, integrated teams consisting of first-, second-, and third-year students learn and practice skills such as design principles, team dynamics, project management, communication, etc., through experiential learning. An added benefit is that having first-, second-, and third-year students work together on the same project fosters a community feeling, enhances a sense of belonging, and strengthens identities.

2. Data acquisition courses. The department combined the electrical engineering and instrumentation courses into a single two-course sequence in the third year of our new curriculum. In the old curriculum, students took a circuits course in the winter quarter of their third year and an instrumentation course the following spring quarter. Students who had taken these two courses indicated that they did not see the connection between the electrical engineering content and their mechanical engineering major courses. This feedback prompted the integration of the electrical engineering and data acquisition courses. In the new curriculum, electrical engineering and instrumentation and data acquisition are taught side-by-side using relevant mechanical engineering problems in a two-quarter sequence. The goal is to provide an integrated experience for students where they learn electrical engineering concepts, apply the concepts to instrumentation, utilize precise measurements, and apply what's learned to their other mechanical engineering courses. The content of this two-course integrated sequence is presented in Ref. [33].

b. Implemented the new ME curriculum. The academic year 2019-20 was the first year of the new curriculum and the pandemic struck in the middle of implementing it. Many adjustments were necessary to carry out the new curriculum during the pandemic, and they are described in detail in Refs. [4], [32], [34] & [35]. Following is a summary of those changes:

1. The first VIDP courses were offered in the spring of 2020 when courses were abruptly moved online, and the second offering in Spring 2021 was delivered entirely online as campus was closed. Although the pandemic altered how the courses were delivered, we were able to keep their essence and adapt to the online format. More details of these adaptions can be found in Refs. [32] & [34]. One important feature to note from the online offerings of VIDP was that each design team still maintained connection with their industry consultants through regular meetings online; these volunteer industry consultants found it more convenient to meet with students virtually than traveling to campus. Preliminary results from inclusion surveys conducted three times through the VIDP courses showed that students felt a greater sense of belonging and inclusion with both their teams and the Department across the course even though they could not meet physically.

2. With the exception of the beginning of the first offering in 2020, the integrated EE and DAQ courses were offered online. The essence of this sequence is to facilitate experiential learning and foster engineering identity by "doing engineering". Because the inability to be physically present in labs could hinder the effectiveness of this sequence, a high priority was placed on redesigning all lab exercises so that they could be conducted remotely by students at home. Lab kits were mailed to students and a list of accessible components to acquire was provided to students. From students' self-reflection exercises, it was demonstrated that remote labs can be

effective for students' learning. Details of the modifications made to implement the lectures and labs remotely are described in Ref. [32].

Other changes made in existing courses including senior design sequence can be found in Refs. [2], [3], [4], [32] & [35].

b. Innovative teaching. The Department has a track record of promoting innovative teaching. For example, some faculty pioneered the inverted classrooms [36], and some championed the authentic problems in classrooms [3], [37], [38]. The new curriculum creates opportunities for faculty to reflect on their teaching and to try new approaches in their classes. Hands-on, project based, collaborative and experiential learning pedagogies are all being utilized by faculty in their teaching. In Ref. [4] & [32], we shared many approaches taken to adapt to remote teaching during the pandemic. Active learning remained a norm even in the pandemic.

c. Extracurricular activities. Although the pandemic prevented us from meeting and interacting in-person, we continued to promote virtual extracurricular activities. The Department hosted events to connect engineers from industry with our students such as seminars and socials and supported student club activities virtually. Even when transitioning back to in-person activities during this new academic year, many events maintained the hybrid format to attract participants who can only join remotely. As our campus reopens, more activities such as drone designs, 3D printing lab socials, and career talks with industry partners are planned to provide more opportunities for students, faculty and practicing engineers to connect outside of the classroom.

Supportive Policies: Changing Expectations in Departmental Reviews and University Policies

Goal:
Culture takes time to grow organically, and changes cannot be forced. A shared vision builds a solid foundation for change. Reflective faculty and a new curriculum create pathways to change. Actions that bring faculty, students and industry together cultivate this culture change of doing engineering. However, these changes in shared vision, faculty, and curriculum would not be sustainable without supportive policies. Therefore, working with other departments, the College, and the University to develop supportive policies is essential for the changes to have long-term impact.

Status.
a. Changes to the annual performance reviews. To incentivize and motivate faculty and to recognize and commend faculty's engagement with industry, the changing culture, and curricular and pedagogical revisions, the Department modified its annual performance review process. For instance, various acts of care for students and innovative teaching approaches are acknowledged by the Chair in faculty's Annual Performance Reviews (APRs). The College APR form also recognizes the value of various types of service faculty do such as mentoring students and contributing to professional societies.

b. Changes to the tenure and promotion guidelines. The Department has also been working closely with the University NSF ADVANCE team to revise the University policies on tenure and promotion [39]. The newly approved promotion guidelines acknowledge a broader range of

faculty contributions in the promotion process, including program and curriculum development, institutional change, student support, service to professional communities, and so on. These also are relevant to sustaining change initiated by the RED project.

c. College-wide and University-wide efforts on diversity, equity, and inclusion.
To build an inclusive environment for our students, efforts need to go beyond the Department. As mentioned earlier, the Department has successfully promoted our diversity and inclusion syllabus statement to other departments in the College and other Colleges in the University. The College also created a Student Advocate position. The Student Advocate resides in the College Advising Center and assists students in navigating through any incident that makes them feel excluded. The Department also supports the College's efforts in raising awareness on DEI issues.

The University began an initiative, "LIFT SU: Inclusive Excellence Action Plan for Racial Equity and Antiracism" in late 2020 [40]. The inclusive culture the Department is developing is aligned with the principles of the LIFT initiatives, and in turn, the University's initiative supports the RED project. We expect more synergy can be created with these College-wide and University-wide movements and our revolution in the Department can lead the change in the College and the University.

Evaluation and research

Goal:
Throughout the project, changes to the program and to student and faculty identities are captured through interviews, surveys, reflections, and audio and/or video documentaries. All students and faculty in the program are invited to participate in these evaluation activities and responses are tracked every year to document the changes.

The three main research questions this project aims to study are:
1. How have the identities of the students and faculty changed?
2. How has the departmental culture changed?
3. What happened in response to changes made in the department?

Brief descriptions of these assessments and their status are presented below.

Status:
a. Identity surveys and Implicit Association Tests (IATs). We track how student's identity changes, using both the explicit identity surveys (ESIS II) and the Implicit Association Tests (IATs). Every year, students participate in ESIS II and IATs and we track the changes of each student's engineering identity throughout the years they are in the program. Details and baseline results of these surveys can be seen in references [41] and [42]. We plan to share more results of these identity studies in future conferences.

b. Alumni and senior exit surveys. We have developed tools to track how students' experiences in the program impact them after they leave the program. Graduating seniors are invited to participate in online surveys about their experience annually and alumni are invited to participate every three years. Results from these surveys will be presented in the future.

c. Growth in professional skills. A pre-post assessment was developed to document how changes made in the senior design sequence, as well as other parts of the curriculum, influence students' professional thinking and skills [3], [4]. The pre-test is administered at the beginning of each senior design sequence and the post survey is administered at the end of the sequence. Preliminary results show noticeable growth in certain professional skills. We continue to conduct these surveys and results will be shared.

d. Inclusion surveys. VIDP courses bring students of different cohorts together. The expectation is that these shared experiences will increase students' sense of being included in their teams and in the Department. An inclusion survey is administered three times across the VIDP quarter. Preliminary results showed that students felt more a part of their teams and the Department by quarter's end, even during the pandemic when all team activities were virtual. The same surveys will be administrated this year when the VIDP courses may be delivered in-person.

e. Reflections. Short reflection activities were added to some classes [43]. These exercises provide a mechanism for students to reflect on what they have learned and its meaning. They also help to document students' experiences in those classes and provide an additional lens for instructors to examine their teaching.

f. External evaluator interviews. An external evaluation team is monitoring the process and progress of culture change in the department by interviewing faculty and students in the Department at least once a year. Based on these interviews, the external evaluator provides suggestions on building and maintaining culture change. The Department discusses those suggestions during the retreat at the beginning of each academic year and identifies action items.

g. Capturing the process. The change process is being documented via additional faculty interviews. These as-yet-unheard recorded interviews will form the basis of a documentary of our journey in changing the culture to be assembled at the end of this project.

Future Work and Long-Term Goals

To build an environment that fosters engineering identity, we are changing the culture of our Department in the four essential areas of shared vision, reflective faculty, relevant curriculum and pedagogy, and supportive policies. In this paper, we shared many actions taken thus far to make this culture change. In the final year of this project, in addition to continuing our efforts in sustaining these changes, we will focus on sharing our experience. The actions we have taken are not limited to our unique setting (i.e., small, teaching focused, mechanical engineering program) and can be adapted to different settings. We plan to broaden our dissemination phase by hosting various workshops and inviting visiting scholars to witness changes in our program.

Our focus on identity can have a long-term impact. It could encourage reflection and a larger discussion about how students see themselves, their education, and their profession. Identity has been shown to be an important factor for women to persist in a field [25]. A culture of "Engineering with Engineers" with incentives and training that promote industry engagement and build strong industry-education connections is essential for technically and professionally

prepared graduates with a practical, realistic understanding of what it is to be an engineer. This culture will in turn cultivate engineering identity. We have invested significant effort to build an inclusive culture and environment to foster engineering identity. It is our hope that our work will provide a clearer understanding of the changes that promote engineering identity and how such identity affects students' sense of belonging in a program and their persistence in the major. We hope that this conversation about engineering identity can lead to a better understanding of how best to create an inclusive environment for all.

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