

## Engineering with Engineers: Revolutionizing Engineering Education through Industry Immersion and a Focus on Identity

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# **Engineering with Engineers: Revolutionizing Engineering Education through Industry Immersion and a Focus on Identity**

## **Abstract**

Identity influences who people think they are, what they think they can do and be, and where and with whom they think they belong. Identity has shown to be a determining factor in one pursuing, persisting, and persevering in a field, and an important factor in attracting and retaining underrepresented minorities. Identity development is a social process realized through culture, through the interactions of students, faculty, and industry, through participation in engineering-related activities, and through reinforcement of shared similarities. 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 practicing engineers that in turn fosters an identity of being an engineer. This culture of “Engineering with Engineers” is created through changes in four areas: shared vision, reflective faculty, relevant curriculum and pedagogy, and supportive policies. In each, a variety of actions create the cultural change, address barriers to change, and ensure sustainability. A common theme unifying these changes is a significant connection to industry. During this project, changes to the program and to student and faculty identities are monitored through interviews, surveys, and portfolios. Results of the study will lead to a clearer understanding of the changes that promote engineering identities and how such identities affect students’ sense of belonging in a program and their persistence in the major. The 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.

## **Background**

There are many definitions of identity; however, the various conceptions fit together. Identity is both within the individual (personal) and without (social) [1]; it is situated in the self and in the groups to which people think they belong [2]. Identity is a consistency of the self across time [3] and a reflection of the individual's environment [4]. People’s identity shapes the experiences they embrace, and reciprocally, those experiences shape their identities [5, 6, 7]. When people identify with an esteemed group, they feel better about themselves and, in turn, they feel better about the group [8, 9]. People behave consistently with their identities [10, 11], choosing behaviors with meanings that match their self-conceptions [12, 13]. In sum, identity influences who people think they are, what they think they can do and be, and where and with whom they think they belong.

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 [11]. Identity is a determining factor in one pursuing, persisting, and persevering in engineering [13, 14]. If one strongly identifies with a group, one is steadfast, defending the group, staying in the group, and supporting the group [15].

With respect to gender, identity is an important factor affecting whether women remain in STEM fields [16]. Park, Cook, Greenwald’s [17] study using implicit measures revealed that identification with STEM may be one of the key factors influencing women’s decisions to persist

in STEM fields. Although women's implicit attitudes toward engineering are positive, women perceive engineering as a male field [17, 18]. When their gender roles and their behaviors (e.g., occupation) don't match, women may experience an identity conflict [19]. This gender role conflict may affect women's attrition from STEM fields [17].

Research shows that identity and fit are important factors affecting persistence in STEM fields for more than just women [5]. When people perceive a fit between themselves and their environments, they persist longer in those environments [20, 21, 22].

The development of identity is a social process. People's thoughts and behaviors are shaped through relationships and reflected appraisals with others [2, 15, 23]; identities are further derived through associations, affiliations, and identifications with groups [15, 24]. Tonso [25] observes that identity development is an enculturated process where identities are acquired through "community-based interactions" and Beam et al. [14] concur that social contexts affect identity.

In engineering education, situated learning is central to identity development [25]. This social process of identity development is realized through the culture of a program- through the interactions of students, faculty and industry, through participation in engineering related activities, and through reinforcement of similarities [13].

## **Objectives**

Recognizing the importance of engineering identity and its possible role in engineering gender and ethnicity gaps, the National Science Foundation awarded Seattle University a grant to study how to build a culture that fosters students' engineering identities and how they affect the persistence and perseverance of students in engineering fields.

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 the identities of engineers.

## **Program Description**

The culture of a program plays a significant role in effective, innovative STEM education [26, 27]. A culture of "Engineering with Engineers" includes creating realistic and practical designs, solving open-ended, unstructured problems, and connecting information from different disciplines to address large-scale systems problems. "Engineering with engineers" also includes having ongoing relationships with practicing engineers, solving problems with them, presenting ideas and results to them, and being critiqued by them. Researchers suggest that doing engineering is especially important for women [10, 25]. Such a culture 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.

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 [28]. It develops organically from the behaviors of a group through association and shared experiences [29]. 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 proposed.

These changes are organized within the four-square typology of change proposed by Henderson, Beach, and Finkelstein [30]. 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. Henderson et al. [30] also identifies several strategies from the literature that represent best practices for successfully cultivating change. 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. With these best practices in mind, actions that are essential to changes in each of the four areas are summarized below. A significant connection to industry girds the culture of “doing engineering” and unifies the changes.

#### *Shared Vision: Building a Culture that Cultivates Identities as Engineers*

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.

#### *Reflective Faculty: Strengthening Interaction with Industry*

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, a part-time Industry Adviser, who has extensive experience in industry and is passionate to engineering education, will provide insights to faculty and students on how to bridge course work and industry practices.

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

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 of freshmen, sophomores and juniors will work together 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 will encourage and sponsor regular seminars, field trips, social events, and Makeathons to connect the program to industry and industry to the program.

### *Supportive Policies: Changing Expectations in Departmental Reviews*

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.

### **Evaluation**

This project will study the effects of a new program culture on the identities of students and faculty, and how these enriched identities affect students' engagement in and commitment to engineering. Results of the study will 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. 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.

These evaluations will focus on three questions:

- *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?*

### **Project Timeline**

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.

Based on the four-categories of changes, the five-year plan of the project is summarized in Table 1. The evaluation process is ongoing, and the results are planned to be disseminated via conferences, workshops, and visiting scholars who will be invited to campus to be immersed in the program for two weeks.

Table 1: Summary of Project Activities and Timeline

|   | Year |   |   |   |   |
|---|------|---|---|---|---|
|   | 1    | 2 | 3 | 4 | 5 |
| <b>Shared Vision</b>                            |      |   |   |   |   |
| Obtaining consensus on the shared vision        | ■    |   |   |   |   |
| Revise department mission                       | ■    |   |   |   |   |
| <b>Reflected Faculty &amp; Industry</b>         |      |   |   |   |   |
| Faculty industry immersion experiences          |      | ■ | ■ | ■ | ■ |
| Faculty training and department vision day      | ■    | ■ | ■ | ■ | ■ |
| Hire Industry Adviser                           | ■    | ■ | ■ | ■ | ■ |
| <b>Curriculum</b>                               |      |   |   |   |   |
| Course development and revisions                | ■    | ■ | ■ | ■ | ■ |
| Offer revised curriculum                        |      | ■ | ■ | ■ | ■ |
| Makeathons, industry seminars, and socials      | ■    | ■ | ■ | ■ | ■ |
| Update and use makerspace                       | ■    | ■ | ■ | ■ | ■ |
| <b>Policies</b>                                 |      |   |   |   |   |
| Revise annual performance review evaluations    |      | ■ | ■ |   |   |
| Revise assessment guidelines and procedures     |      | ■ | ■ |   |   |
| <b>Evaluation and Research</b>                  |      |   |   |   |   |
| Student & faculty surveys, IATs, and interviews | ■    | ■ | ■ | ■ | ■ |
| Required student portfolios and reflections     |      | ■ | ■ | ■ | ■ |
| Campus visits by external evaluator             | ■    | ■ | ■ | ■ | ■ |
| <b>Dissemination</b>                            |      |   |   |   |   |
| Conferences                                     | ■    | ■ | ■ | ■ | ■ |
| Workshops                                       |      | ■ | ■ | ■ | ■ |
| Visiting scholars                               |      | ■ | ■ | ■ | ■ |

**Current Status**

This five-year project is in its inaugural year. At the current stage, significant efforts have been devoted to implementing the shared department vision. Faculty are reaching consensus on bringing industry practice to our students and sharing the vision of “Engineering with Engineers.”

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. With input from current students, the faculty have begun revising the curriculum so that it aligns with the shared vision. The proposed curriculum will center around a series of vertically integrated courses that focus on industry related learning experiences and will be rolled out in Fall 2019.

Seminars, field trips, and social events to connect faculty, students and industry are on-going. The Industry Adviser has been hired and has begun interacting with faculty and students. Leads to faculty industry immersion experiences are being identified. Faculty trainings are being planned.

Policies on tenure and promotion standards are being discussed at the university level per the ADVANCE program sponsored by NSF [31]. Conversations regarding annual performance reviews are underway.

Baseline explicit identity surveys for existing Mechanical Engineering students were conducted and results will be presented in the 2018 ASEE annual conference [32]. Additional baseline engineering and gender identity data were collected via Implicit Association Tests (IATs) in early Spring 2018. Example portfolios were collected from current students to gain insights on students' knowledge on portfolio construction and help set goals on portfolio activities. The change process is being documented. Additionally, an external evaluation team is monitoring the process and progress of culture change in the department and their findings will be used to examine the activities in the program. These and future results will be disseminated via conferences, workshops, and publications.

### **Long-Term Goals**

Results of the study will lead to an understanding of what changes in shared vision, faculty, curriculum, and supportive policies promote engineering identities, particularly in women and underrepresented minorities, and how such identities affect students' sense of belonging in a program and their persistence in the major. The 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. In addition, this project will enact changes in incentives and training that promote industry engagement and build strong industry-education connections.

Finally, 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. This conversation can lead to a better understanding of how best to create an inclusive educational system.

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