Work-in-Progress: Engineering Identity across the Mechanical Engineering Major

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Abstract

The Mechanical Engineering Department at Seattle University was awarded a National Science Foundation RED (Revolutionizing Engineering and Computer Science Departments) grant in 2017 to study how student identities change when a department makes "revolutionizing" changes. These changes will be implemented over the next five years in four areas research shows are important: shared vision, reflective faculty, relevant curriculum and pedagogy, and supportive policies. The goal of the changes is to immerse students in a new culture of "Engineering with Engineers" throughout their years of studying mechanical engineering. This paper focuses on the identity data collected during the first year of the grant, and describes the theoretical background, methodology, and the results. These data will serve as a baseline for the ongoing identity research supported by the grant.

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 [1-13]. In academic contexts, identity influences whether people feel they belong in a program and what they believe they can achieve; it affects what goals they pursue, and the level and type of effort put towards those goals [11]. When people perceive a fit between themselves and their environments, they persist longer in those environments [14-16]. In engineering, identity is an important factor in people pursuing, persisting, and persevering [13, 17]. Brainard and Carlin's [18] longitudinal study found that freshmen students' identities were better predictors of long-term persistence than even GPAs or self-efficacy.

Lee [12] showed that identity is an especially important factor affecting whether women remain in STEM fields. Park, Cook, Greenwald's [19] study using implicit measures revealed that identification with STEM may be one of the key factors influencing decisions to persist in STEM fields. Although women's attitudes toward engineering are positive, women perceive engineering as a male field [19, 20]. When their gender roles and their behaviors (e.g., occupations) don't match, women may experience identity conflict [21]. This gender role conflict may affect women's disproportionate attrition from STEM fields [19].

Although identity theory has been heavily researched in psychology [1-12, 15-16, 22], it has not been a focus in engineering [13, 17]. Few studies investigate how developing an engineering identity would improve the recruitment and retention of engineering students, especially of women and underrepresented minorities. Recognizing that engineering identity is understudied, and that it could be a factor contributing to 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 such engineering identities could affect the persistence and perseverance of students in engineering fields. Details on the changes being made to build this culture in an Mechanical Engineering department are described in a paper presented in the 2018 ASEE NSF grantees division [23].

Because identity influences people's belonging, goals, efforts, commitment, and perseverance, and because identity may play a role in attracting and retaining engineering students, it is important to understand students' identities. Understanding students' current identities is critical to evaluating the impact of future program changes, and to elucidating where changes might be most effective. This paper presents the results of an identity survey that addresses the following questions: Do students identify with engineering? Do identities vary across years of the program? Do students' identities differ by gender or other demographic variables? Answers to these questions will serve as a baseline for a five-year study assessing the impact on identity of our Mechanical Engineering program changes.

Method

All undergraduate students enrolled in the mechanical engineering program of a private, mid-sized university were invited to participate. The program utilizes a cohort model where all students at each level (freshmen, etc.) take at least one of the major's courses together. One of the authors not teaching any of these courses visited each cohort's classroom and invited students to access the Qualtrics survey using their devices (phone, laptop, etc.). Students who gave consent completed five demographic questions (age, year in school, whether a transfer student, and perceived gender and ethnicity) and the revised Engineering Student Identity Survey, ESIS-2 [24].

ESIS-2 Survey. Recognizing the centrality of identity to persistence in the major, Pierrakos et al. developed the E-SIS to measure the identity of engineering students on the following dimensions: unified self-concept, distinctiveness, participation, self-enhancement, social support, in-group cooperation, visibility of affiliation, sense of belonging, citizenship behaviors, interest, and attitudes toward becoming an engineer [16]. The original E-SIS [16] was based on identity theory as well as interviews and surveys of engineering students [13, 25]. Efforts to refine the E-SIS resulted in the 37-item ESIS-2 [24]; the ESIS-2 includes such questions as, "I feel like I embody what it means to be engineer," and, "I feel that I fit in with other engineering students". Students responded to each question on a Likert scale from *Almost Always* to *Almost Never*. Possible total scores thus range 37 to 222, with lower scores representing a stronger engineering identity. In the participating sample, Cronbach's alpha for the scale was .949.

Sample. Seventy-five students (52 men, 22 women, and 1 unspecified) from a program of 111 students with an average age of 20.5 (SD= 2.4) completed the ESIS-2. The sample was predominantly white (53.3%) with the next largest group identifying as Asian (20%); 12% indicated other, 6.7% Black or African American, 5.3% Hawaiian or Pacific Islander, and 2.7% didn't specify. Transfer students made up 24% of the sample.

Data from the ESIS-2 were used to determine if students identify with engineering, if engineering identities vary across years of the program, and if identities differ by gender or other demographic variables.

Results

Do students identify with engineering? Scores on the ESIS-2 in this sample ranged from 37 to 159 (possible range is 37-222), indicating that all participants have some identity with engineering. The sample's mean score of 95.11 (*SD*= 27.24) is in the top third of possible scores and reflects that students typically responded, "Usually" or "Often" to the survey items. The mean and typical responses show that students have moderate engineering identity.

Do students' identities vary across years of the program? Table 1 shows participants' ESIS-2 scores by year in school. While students have lower scores in their junior and senior years suggesting stronger identities, these differences were not significant, $F(3, 70) = 835$, $p = .479$. Because of the relative smaller sample size of the freshmen and sophomore groups, they were grouped and lower- and upperclassmen's ESIS-2 scores compared. Freshmen and Sophomores' identity [ESIS-2 mean of 101.59 (*SD*= 29.25)] did not significantly differ from 5th year, Seniors, and Juniors' identity [ESIS-2 mean of 91.53 (*SD*= 25.82)], $t(72)= 1.49$, $p= .141$. The especially small sophomore sample suggests that their high ESIS-2 score may not be reliable or representative.

Table 1. Mean and SD of ESIS-2 scores for each grade level; one participant did not indicate grade level. There were three 5th-year seniors. Lower scores represent stronger engineering identities.

Year in school	N	Mean	SD
Freshman	16	99.81	27.99
Sophomore	7	105.65	33.91
Junior	19	89.84	24.49
Senior and 5th	32	92.53	26.90

Year in school	N	Mean	SD
Lower Classmen	23	101.59	29.25
Upper Classmen	51	91.53	25.82

Do students' identities differ by gender or other demographic variables? The various subgroups did not differ in engineering identity. Men and women's ESIS-2 scores were essentially the same, $t(52.81)= .037$, $p= .970$, as were transfer and non-transfer students $t(72)= .100$, $p= .921$, and white and nonwhite groups, $t(72)= .119$, $p= .905$. See Table 2.

Table 2. Mean and SD of ESIS-2 scores by gender, transfer group, and ethnicity; one participant did not indicate gender, one did not indicate transfer status, and one did not indicate ethnicity. Lower scores represent stronger engineering identities.

Gender	N	Mean	SD
Male	52	94.72	29.31
Female	22	94.49	21.75

Transfer?	N	Mean	SD
Yes	18	95.22	28.95
No	56	94.48	26.80

Ethnicity	N	Mean	SD
White	40	95.00	27.11
Nonwhite	34	94.24	27.56

Discussion

Undergraduate Mechanical Engineering students at this private, mid-sized university indicated that they "Usually" or "Often" engaged in thoughts, feelings, or behaviors that reflect having an engineering identity. While highly variable (with a large range and standard deviation), students' average score was in the top third of possible ESIS-2 scores reflecting that these students hold engineering identities [24]. There is room, however, for most to increase their identification.

Students' engineering identities did not vary by their group memberships. This finding runs counter to prior work suggesting that women and underrepresented minorities identify less with STEM fields. However, sample sizes for women and underrepresented minorities were small, which ironically may reflect the lack of engineering identification in these groups.

It also is possible that the ESIS-2 was not able to distinguish among students' engineering identities. Research with implicit measures suggest that they may be able to assess psychological constructs such as identity at a finer level [26]. The authors will use the Implicit Association Test [27] to assess and compare these Mechanical Engineering students' identification and results will be reported in the future.

Deeply understanding the identities of women and underrepresented minorities will guide reforms aimed at strengthening the identities of students in the program and discerning why other students are not. By understanding students' current identities, we will be able to gauge the impact of future program changes on engineering identities.

Conclusion

Because identity is an important factor in determining people's sense of belonging, goals, efforts, commitment, and perseverance, it has a role to play in efforts to attract and retain engineers, especially underrepresented minorities. As we revamp our Mechanical Engineering program as described in the 2018 ASEE NSF grantees division, we will pay special attention to how identities, especially those of the underrepresented, are affected by the changes made. What we learn will lead to a clearer understanding of the changes that promote engineering identities, and how such identities affect students' belonging in the program and persistence in the major.

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