Development of Engineering Identity

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Abstract

Academic success of students in engineering has been reported in research literature to be correlated to the development of their engineering identity. This paper provides results of a cross-sectional study of undergraduate students' development of engineering identity at a Historically Black College/University (HBCU). A validated 11-item questionnaire on engineering identity was administered to freshmen through seniors. The data was analyzed to determine correlations between engineering identity, time spent in college, and academic success. This work is supported by NSF Grant# 1832041.

Introduction

The number of engineers in the US with an undergraduate degree in engineering is well below the need, and this gap is projected to grow over the next five years. For example, it has been reported that by 2025 more than two million jobs requiring science, technology, engineering and mathematics (STEM) background will be unfulfilled[1].

The number of college degrees awarded in STEM fields are much smaller in comparison to other countries such as China[2]. While there was a steady rise in undergraduate enrollment in science and engineering (S&E) from 2000 (243,500 students) to 377,410 in 2014, this is in stark contrast to China where in 2000 the undergraduate enrollment in S&E was 281,270 and in 2014 it was 1,447,330[3]. In 2014, 40 percent of bachelor's degrees earned by men and 29% earned by women were in STEM fields. The engineering degrees were only 4.4% of all the undergraduate degrees awarded in 2014 as compared to for example, European countries (13%) or Asian countries (23%), according to a report by the National Academy of Engineering[4].

President's Council of Advisors on Science and Technology noted in its 2012 report[5] that less than 40% of the undergraduates planned to major in STEM. While attracting students into STEM is one aspect of the problem, retaining those who indicate interest in STEM is the other end of the challenge. The six-year graduation data for the 2003-09 cohort published in 2014 by the National Center of Education Statistics[6] reported that 48% of those who entered college as STEM students either changed their major to a non-STEM major or left college without obtaining a degree. In 2016, only 4% of African-Americans received an engineering degree[7]. The six-year degree completion rate in STEM was less than 40%, and persistence of females, and racial and ethnic minorities

underrepresented in STEM is even lower than the average completion rate[8]. The ASEE reported[9] that while the six-year engineering degree completion rate was about 60% for White students, it was about 35% for African-Americans.

These statistics translate to an engineering workforce inadequate in numbers, and that lacks diversity which is a valuable contributor to development and innovation[10]. Underrepresentation of minorities (e.g. African American, Latino, women) in STEM careers is well documented. Landivar[11] noted that in 2011 Blacks were 11% of the total workforce, but only 6% were employed in STEM-related careers. This was in contrast to Whites who were 71% of the workforce with 67% of them in STEM careers. It is pertinent to point out that according to the 2015 census[12], Blacks/African-Americans were 13% of the US population and Whites were 72% of the population. While there are several structural reasons for this disparity[13], one of the challenges is the retention of underrepresented students in STEM disciplines in college. A literature study[14] in 2013 identified six factors resulting in students to leave engineering, these being (i) classroom and academic climate, (ii) grades and conceptual understanding, (iii) self-efficacy and self-confidence, (iv) high school preparation, (v) interest and career goals, and (vi) race and gender. These factors map onto the more general constructs of engagement, self-efficacy and motivation.

The relation of professional identity with academic success has been identified for students from lower socio-economic status and underrepresented groups[15,16]. The use of professional identity as 'lens' through which marginalization and disengagement can be studied has been proposed[17]. The interconnection of engineering identity and engineering education has also been reported[18,19]. A correlation between engineering identity and persistence has also been reported[20]. Thus, to support academic success, engineering education must be informed by an understanding of engineering identity. A review by Morelock[21] has categorized research literature on engineering identity by (a) definition of engineering identity, (b) factors impacting development of engineering identity, (c) interventions for developing engineering identity, and (d) measurement of engineering identity. It was noted that engineering related experience and engineering related connections were two important aspects identified for developing an engineering identity. 'Engineering practice factors' such as tinkering, design, analysis as meaningful predictors of engineering identity[22].

The present study is directed towards understanding the development of engineering identity of students at a Historically Black College/University (HBCU) and its relationship to academic success. The objective of the research is to provide an empirical basis for driving curriculum and pedagogical changes.

Method

The study was a quasi-experimental between groups research design. The engineering identity survey developed by Godwin[23] was administered electronically to engineering students during the 2018-19 academic year. This 11-item Likert scale survey which measures the interest (3-items), performance/competence (5-items) and recognition (by others) (3-items) dimensions of engineering identity has been validated in a later study[24] as well. A total of 143 engineering students responded to the survey. Of these respondents, 99 were freshmen (8 females, 91 males), 16 were sophomores

(2 females, 14 males), 14 were juniors (3 females, 11 males), and 14 were seniors (2 females, 12 males).

Results and Discussion

The responses were averaged for each of the three dimensions (recognition, interest, performance /competence) based on the academic standing of the respondents. These averages are shown in Fig. 1. There was little change in the average of responses to the items of the performance /competence dimension for freshmen (3.96) and sophomores (3.98). However, the average for juniors was 4.38. The average of responses for seniors was 3.98. This lower average of seniors was investigated to see if academic performance (GPA) had any impact. No correlation with GPA was observed for the lower average in the performance/competence dimension of the seniors as compared to juniors. A one-way analysis of variance (ANOVA) did not show any statistically significant difference between the four groups.

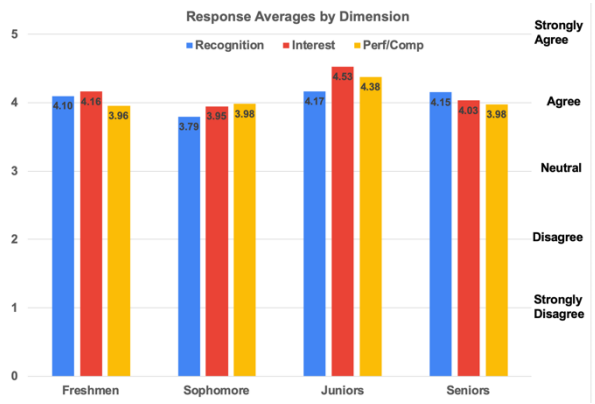

Figure 1. Average of Responses to the three dimensions

There was a slight decrease in the 'interest' dimension from freshmen (4.10) to sophomore (3.95). The juniors reported a much higher average (4.53), while the seniors average of the responses to the items of the 'interest' was 3.98. The average of the 'recognition' dimension was the lowest for sophomores (3.79), whereas for freshmen, juniors and seniors it was almost similar being 4.10, 4.17, 4.15 respectively.

The 'recognition' dimension was explored further. The responses by all participant students to the three questions of the recognition dimension are shown in Figs. 2 – 4. It can be seen from Fig. 3 and Fig. 4 that on the average almost 30% respondents were neutral or not-sure about their parents or instructors recognizing them as engineers. Fig. 6 indicates that they had strong peer recognition as engineers.

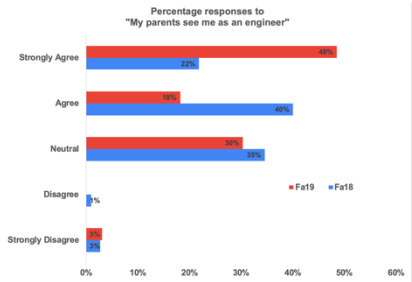

Figure 2. Recognition by parents.

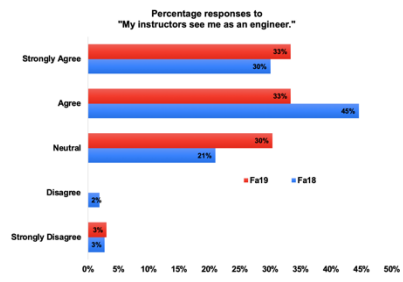

Figure 3. Recognition by instructors

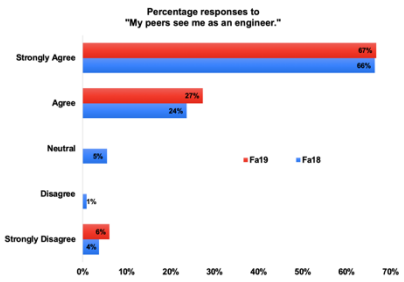

Figure 4. Recognition by peers

Responses to individual question were analyzed to identify any specific reasons for the lower averages of seniors to the 'interest' dimension. The analysis of a few questions is presented. In Fig. 5, the responses to the statement "I am interested in learning more about engineering", an item of the 'interest' dimension are plotted. It was observed that a large percentage (27%) of seniors were neutral or not sure about how they felt about this statement. In contrast only 8% of juniors had a neutral or not-sure response to this question. Similarly, the neutral or not-sure responses to the statement "I enjoy learning engineering" was 36% for seniors as compared to 8% for sophomores (Fig. 6). And, surprisingly 18% of seniors disagreed with the statement "I find fulfillment in doing engineering" (Fig. 7).

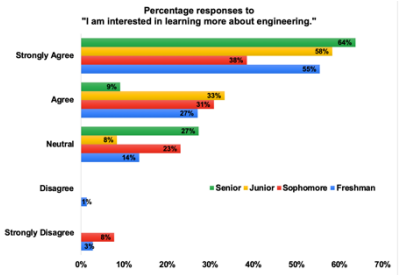

Figure 5. Interest in Learning.

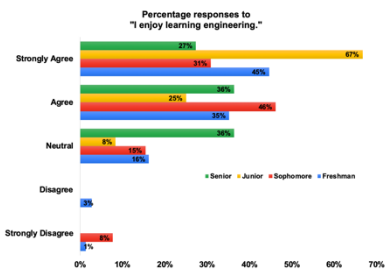

Figure 6. Enjoyment in Learning.

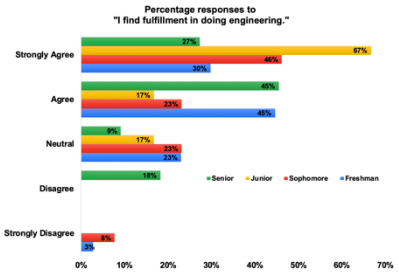

Figure 7. Fulfillment in Learning

The responses to the statements included in the 'performance/competence' dimension were analyzed to identify trends. The neutral or not-sure responses by seniors to the statement "I am confident that I can understand engineering in the class" were 18% while there were no responses in this category by the juniors (Fig. 8). The seniors lower self-efficacy was evident from their 38% neutral or not-sure responses and 9% disagree responses to the statement "I am confident that I can understand engineering outside the class" (Fig. 9). Again, there was no response in the neutral or not-sure category to this statement by juniors as they were quite sure about their ability. The 18% of the seniors either were not sure or did not agree with the statement "I can do well on exams in engineering". In contrast 100% of the juniors agreed or strongly agreed with the statement that they can do well on exams in engineering (Fig. 10).

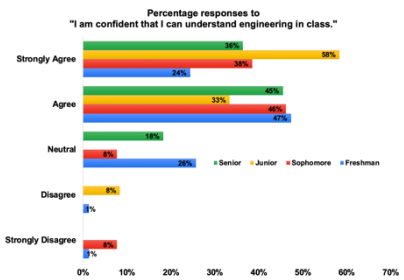

Figure 8. Understanding in class.

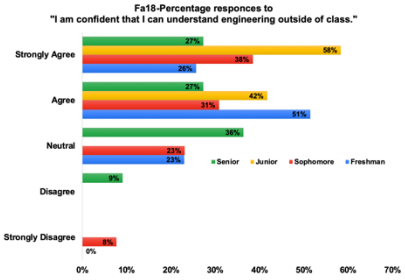

Figure 9. Understanding outside class.

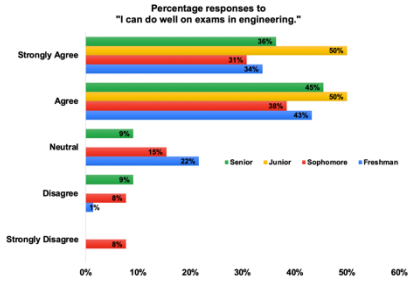

Figure 10. Performance on exams

The analysis indicated a reduction in the engineering identity of seniors on the 'interest' and 'performance/competence' subscales of the engineering identity survey. The analysis of individual questions shows that the primary reason was that the large percentage of seniors were 'not-sure' or 'neutral' towards the statements of these two subscales.

Summary and Conclusions

The analyses indicated an interesting pattern in the cross-sectional development of student engineering identity. The self-perception of freshmen and seniors were almost similar in the three dimensions of engineering identity. The juniors exhibited the highest means in interest and performance/competence. These results provide some basis of engaging the seniors in understanding the reasons of their ambivalence towards interest and lower self-efficacy of performance/competence. Interestingly, the means of the responses of the sophomores were the lowest in the recognition and interest dimensions. It was also observed from the analysis that the respondents were not-sure if their instructors recognized them as engineers. This observation is a useful data point for instructors to be cognizant of, and introduce deliberate pedagogical interventions to support the 'recognition' dimension of engineering identity.

Acknowledgments

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