Work in Progress: Engineering Identity Development after Two Years of Undergraduate Education

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Engineering Identity Development After Two Years of Undergraduate Education

Background/Motivation

Students from low-income backgrounds (hereafter referred to as low-income students) have high aspirations, drive, motivation, and interest in attaining college degrees [1]–[3], yet, they are also more likely to have attended underserved primary and secondary schools and therefore more likely to be underprepared for engineering studies in higher education [4], [5]. The financial need to complete higher education in the field of engineering is high for these students [6]. However, it is not the only variable necessary for their success. Aside from financial support, low-income students may need academic, professional, social, and emotional support [7]–[9]. Without these supports, low-income students are more likely to leave higher education and not complete their degrees [4], [5], [10]. While institutions of higher education do address these needs in the form of financial assistance, and programs, sustaining policies and cultural change that address the college experiences of these students are still needed.

One way of understanding the cultural change necessary to ensure minoritized students are successful in engineering has been through the study of engineering identity. The necessity for continuing studies about engineering identity development of low-SES students must be emphasized to address cultural change and systemic opportunities within departments of engineering. The steady increase of ethnic minorities in the United States is rapidly changing the dynamics of the national population and the education system [5]. Thus, low-income students will soon make up a more significant proportion of students in the nation's schools and STEM-related careers [5]. Quality education must be made available for low-income students to strengthen the workforce [5], [6]. Identity research, therefore, provides a lens to explain how students identify with a particular field and seek to improve their persistence [11], [12] as well as provide a way to address system-level opportunities for change. The purpose of this research study is to help educators develop a more inclusive engineering education environment and promote cultural change that leads to positive and fulfilling college experiences for low-income students. We believe that cultural change can be achieved via an understanding of how students develop their engineering identity. In other words, how they identify with the field of engineering and are identified by others within the field. Inclusivity, in this case, would be emphasized by how students' identities are valued and understood within an engineering environment. Additionally, via the use of identity research, we aim to provide insight into how low-income students make meaning of their engineering experiences [13], [14].

This paper focused on the first two years of a larger, longitudinal study of engineering identity development of low-SES, high-achieving undergraduate engineering students. The goal of this paper is to show the various factors contributing to students' engineering identity development after two years of undergraduate education, particularly the participants of this study. Determination of low-income status and high-achieving status is discussed in more detail in a previous publication [15]. In short, low-income status was determined by the institution's financial aid office using FAFSA and student's unmet need. High-achieving status was

determined by the students' institutional Selection Index, which is a weighted calculation of high school GPA and standardized test scores at the time of application to the institution.

Literature Review

Research on engineering identity emerged from various academic strands, including psychology [16] and sociology [17]. In this study, we define identity as "being recognized as a certain 'kind of person' in a given context"[12]. The given context focuses on an individual's social performances rather than on their uniqueness. In addition to being recognized by others, self-recognition is also included in our identity definition. Reviews of literature that summarize this construct's emergence within engineering education have been previously published [18], [19].

Despite the increase in the numbers of low-income students, they continued to lack commensurable representation in four-year universities compared to their high-income counterparts [2], [9], [20]. The financial challenge faced by low-income students does not only inform their aspiration, choice, and participation in higher education [21]; financial difficulties can also affect access participation and barrier to success [22]. In spite of all the challenges faced by low-income students, there are other important influences in their pursuit of higher education [2]. Strutz & Ohland [2] identified why low-income, first-generation students pursued engineering studies. Strutz & Ohland identified four reasons why the participants pursued careers in engineering: "1) elements of engineering experienced in informal learning; 2) their self-identified attributes and interests and advanced skills; 3) their understanding of the image of the field of engineering; and 4) STEM knowledgeable individuals who offered encouragement, support, and perspective" (p.25). Yet, as found in [23], low-income engineering students may perceive different barriers compared with high-income engineering students.

Identity development is fluid and non-static [24]. Hence, the prevalence and salience of identity fluctuate with the environment, context, engagement, interest, socialization, and alienation experiences. Engineering identity development could be used as an analytic lens to study marginalization and disengagement within and from the engineering community [25], [13]. In doing so, the onus on pertinent outcomes (e.g., retention, graduation, post-graduation employment, or graduate school) is placed on not just the student, but also on the institution especially if it harbors engineering culture that impedes engineering identity development.

Framework

An integrated engineering identity conceptual framework, including the science identity model [25] the model of multiple dimensions of identity[24] , and aspects of community-based dimensions of engineering identity [26], guide this work and can be seen in Figure 1. The science identity model posits that recognition, competence, and performance are important principles for engineering identity development. There are four interrelated dimensions of science identity in this integrated model (see figure 1), combined with other identities (e.g., gender, religion, ethnicity) that students develop in a fluid and dynamic way and that shapes their engineering

identity [22]. Carlone and Johnson's science identity model [25]has been used as the basis to develop a construct for engineering identity within the engineering education community. The science identity model advances that identity develops in an intersectional way and over time.

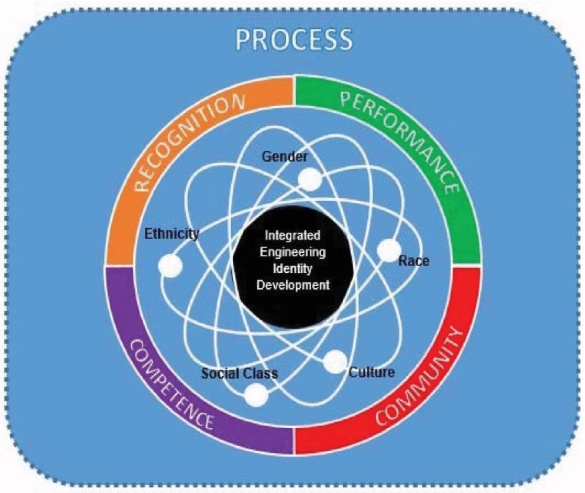

Fig. 1. Integrated Engineering Identity Development Framework

At the outset of the framework (shown in Figure 1), following the work by [25] , we posit that recognition, competence, and performance are essential pre-college tenets for engineering identity development [27], [28]. Similarly, we add community – being part of a community of engineers – as an important tenet for the same goal. According to Carlone and Johnson [25], recognition is the most critical tenet of the science identity model, and it captures recognizing "oneself "and getting recognized by others as a "science person" [p.1191]. Performance captures "social performances of relevant scientific practices" [p.1191]. Competence captures "knowledges and understanding of science content" that "may be less publicly visible than performance" [p.1191]. Community captures the group(s) of individuals that create an environment conducive to engineering identity development.

Nestled inside the identity tenets (i.e., recognition, performance, competence, and community), we place the Model of Multiple Dimensions of Identity (MMDI) and posit that engineering dimensions are interconnected with other forms of identifying (e.g., race, gender, ethnicity) in the development of engineering identity. The MMDI offers a contextual and fluid understanding of college student identity development. In particular, at the center of MMDI is the core of "self" that remains unchanged regardless of the context (e.g., socio-cultural conditions, current experiences). Ways of identifying (e.g., race, sex, religion) surround the core, cannot be understood in isolation, and their salience can change based on the context. Previous research [16], [21] has used the MMDI to understand engineering identity development alongside other ways of identifying (e.g., race, ethnicity, gender).

Methods

Research Question

This work is built on the first-year understanding of engineering identity profiles and identification with the field developed from the analysis of the pre-college and first-year interviews with participants [29]. The results presented in this paper provide a preliminary analysis of how the development of engineering identity progresses after two years of university. The guiding question is, how do engineering students from low-income backgrounds develop their engineering identity after two years of undergraduate education?

Data Source & Collection

Although this study is part of a larger longitudinal study, the data analyzed for this paper entails that of only one year of the larger study. This study implements one-on-one, semi-structured interviews of undergraduate students from eight engineering majors: biomedical engineering, chemical engineering, civil engineering, computer engineering, computer science, electrical engineering, industrial engineering, and mechanical engineering. These students were also part of a financial, professional, and academic support program. More details of the program and how the students were selected for it are detailed in [15]. The interviews analyzed for this work-in-progress paper were conducted during the summer of 2020. All the study participants were invited to the interview, and 12 of the original 13 participants were available. The average interview length was 35 minutes. The lead author interviewed the twelve participants with a protocol focused on understanding the students' engineering identity via the use of an integrated model of engineering identity. The flexibility of semi-structured interviews helped generate relevant follow-up questions during the interviews and finetune the following protocol interview for a richer data collection [30].

Data Analysis

The interviews were transcribed verbatim and MAXQDA software was used for analysis. Because this project is a work-in-progress, we are currently finishing the first cycle of coding done individually by three of the authors. For this cycle of coding, we are using deductive coding analysis guided by the framework and a codebook from the baseline interviews with the same cohort of students, as reported in [26]. The multiple cycles of coding working together and individually by different researchers provide trustworthiness in the study [31]. The preliminary results shared in this paper summarize the working prevalent codes using our working codebook. After at least two cycles of group coding, we expect to generate prevalent themes to publish in a follow up report.

Preliminary Results & Discussion

The engineering identity tenets of competence, recognition, performance, and community are evident in the students' development after two years of undergraduate education. Family

continues to be a primary influence on students engineering identity development; the students also serve as role models for other family members. The students' view of socioeconomic status is linked to their "understanding of money" regarding access to resources, family structure, and motivation for engineering. Recognition as an engineer continues to be significant. Most of the self-recognition after the second year was conditional on a tangible marker, such as attaining a degree, gaining more industry experience, or taking more engineering classes. The preliminary, prevalent codes from our individual analysis of the data are shown in Table 1.

TABLE 1 Sample Codebook for Year 1 Interviews

	Code	Description
1.	Support from family	Family continues to be a big drive for students,
2.	"Understanding of money"	Students' understanding of money is in relation to student loan, SES, motivation etc.
3.	Coursework as a measure of competence	Success in coursework served as a tangible marker for competence
4.	Conditional recognition	Students self-recognized as engineers based on coursework already taken and future coursework.
5.	Performance	Performance in internships
6.	Gender	A contextual influence for students

Other factors such as other ways of identifying (e.g., race, gender) and contextual influence (e.g., family background, socioeconomic status) contributed to the students' engineering development, showing that identity development does not happen in an isolated manner [31]. The continued change in students' narratives of their engineering identity suggests the learning and growth that has occurred. Our preliminary results show that these students have developed their engineering identity concerning competence, performance of engineering skills, and intersections of identity development for women about gender and engineering, which seem to be critical. At this stage, students embrace and rationalize this intersection from an asset-based perspective.

Limitations and Implications for Future Research

This research paper is part of a longitudinal study investigating how low-income, high-achieving engineering students develop their engineering identity throughout their undergraduate education at a four-year university. Because the study focuses on a particular group of students in a specific context, the questions and participants' responses are geared directly to how they develop their engineering identity within the second year of their program. The scope of this study is limited to the participants of the study, exclusive of non-participating students both low-income, high-achieving engineering students and others. As a result, it is not possible to examine the engineering identity of students leaving engineering programs. Nonetheless, it has implications for practice, especially in support of low-SES, high-achieving students.

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