Work in Progress: Survey Development of Factors Related to Engineering Graduates' Career Pathways

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WIP: Survey Development of Factors Related to Engineering Graduates' Career Pathways

This work in progress paper describes the motivation for and development of a survey instrument to collect information about engineering graduates' career pathways. In this work, we begin to reframe interpretations of what it means to be an engineer and understand why alumni make particular career choices. The survey will be distributed to graduates of engineering departments at a single institution. Items will include job titles, job sectors, perceptions of relatedness to engineering, job experiences and beliefs, and engineering experiences and beliefs. These data allow for increased sensitivity to the multiple pathways that graduates may take, as well as how alumni may connect with engineering even when employed in non-engineering positions. We discuss the descriptive and predictive power of the survey in understanding the career landscape for engineering graduates and key factors that may influence their decisions.

Introduction

In engineering and beyond, career choices and pathways are of vital importance. In addition to providing wages, career choices are a form of self-expression and can foster identity development [1]. Awareness of careers develops at a young age, often focused around what children want to do when they grow up [2]. Entire fields of vocational, organizational, and industrial psychology are dedicated to understanding experiences preparing for and being in the workplace. Given the importance of understanding the career preparation process, researchers should endeavor to develop knowledge that reflects the lived experiences of individuals making decisions about their future careers.

In engineering education, two gaps in the literature currently limit the extent to which career research reflects individuals' lived experiences. First, existing studies in engineering education research often make assumptions of what "counts" as an engineering career. Typically, only positions in industry or academia in engineering sectors are counted towards retention. Second, studies often treat career decision-making as a logical, cognitive process, ignoring the pervasive influences of personal identities and belonging. The proposed study has implications not only for improving the verisimilitude of career research, but also for broadening participation in engineering to individuals with career goals other than the engineering profession.

Literature Review

Previous studies on career choice in engineering have found that many engineering graduates do not remain in engineering positions or do not enter the engineering profession entirely [3]–[6]. For instance, the Science and Engineering Indicators 2018 Report found that, for individuals whose highest degree was in engineering, 42% were employed in a non-engineering role [7]. Interestingly, the report also found that 90% of these individuals saw their jobs involving some sort of engineering [7]. Given the high proportion of engineering alumni in non-engineering careers, it is imperative that the engineering education research community seeks to understand the ways in which all graduates perceive the utility of their engineering degree.

Although the field of engineering education research has devoted significant efforts to the career pathways of engineering graduates, these efforts often take a diffuse view of what "counts" as an engineering career. Previous career pathway studies classify careers through alignment with

existing job titles [8] or through self-reports that the job is in the engineering profession or "related" to engineering [9]. Indeed, Sheppard and coauthors noted that "what is characterized as engineering work remains undefined" [9, pp. 306]. The lack of agreement with respect to how to measure career pathways has led to a literature base that cannot yet make claims about the ways in which individuals in non-engineering careers remain connected to engineering.

Similarly, the lens through which career decision-making processes has been conceptualized limits certain ways of being and knowing. Social Cognitive Career Theory (SCCT) [10] is heavily used in engineering education research, both in quantitative [11], [12] and qualitative studies [13]–[15]. Although SCCT identifies personal inputs, background contextual affordances, and contextual influences, the theory emphasizes the progressive relationship between interests, goals, and experiences [16], [17]. A broader perspective of career thinking can be achieved through the addition of constructions such as engineering identity and belonging. In this study, engineering identity is conceptualized through a role identity framework [18]. Belonging has been identified as a key reason that undergraduate students leave engineering [19], [20].

Finally, when considering attrition from the engineering profession, the experiences and pathways of women have been a strong focus within the literature. Women are underrepresented in engineering education and even more underrepresented in professional engineering, making up around 15% of engineers [21]–[23]. These numbers have remained consistent over several decades despite conscious efforts and interventions [1], [21], demonstrating the need for greater understanding the engineering career thinking that women engineering students engage in. By examining possible connections to engineering outside the engineering profession, researchers can gain a new perspective into the goals and beliefs that engineering students have when thinking about the future.

Purpose, Study Context, and Research Questions

The purpose of this study is to investigate the career pathways that engineering graduates take, while being as sensitive as possible to participants' perceptions of their careers. To aid the ability to interpret the data, a single institution was chosen. This institution is a large land grant university in the Midwest United States, with over thirty percent of its students majoring in engineering. While the results from this study may not be transferable to all engineering education programs, similar results might be expected for large public institutions with significant engineering populations. Two research questions guide this study:

> *RQ1: What are the career paths of engineering graduates from biomedical, chemical, and mechanical engineering?*
>
> *RQ2: What beliefs and experiences influence these pathways?*

Methods

Participants

The targeted participants of this survey are alumni of engineering undergraduate programs at a single institution. This alumni base contains over 80,000 individuals, who will be contacted electronically through the institution's alumni association. Electronic surveys typically have a response rate between ten and fifteen percent; thus, we expect around 8,000 participants in total. This deployment strategy allows for a full perspective on the possible career pathways after graduation. This study is approved under the institution's IRB.

Measures

The proposed survey is divided into five parts: (1) characterizing the participants' post-baccalaureate pathways, (2) describing their undergraduate and workforce experiences, (3) measuring attitudes and beliefs about engineering, (4) identifying people and experiences that influenced participants' choices, and (5) collecting demographic information. First, to characterize career pathways, we ask participants to identify the number of career positions that they have experienced, including educational opportunities and periods of unemployment. For each position where the participant was an employee, we ask participants for the job title, occupational sector (e.g., public, private, etc.), and industry sector (e.g., manufacturing, finance, etc.). This characterization departs from prior work on career pathways, which aligned pathways with Bureau of Labor Statistics categories of industry and occupational sectors [8]. Instead, participants are asked to write-in their job title and select from recognizable industry sectors that commonly employ engineering graduates. For positions that where participants identify as being students, a write-in box will capture the degree conferred (e.g., PhD, JD, etc.) and the field of study. Beyond the title and sector for the positions, this pathway characterization also asks participants to share their binary (yes/no) perceptions of relatedness to engineering, the extent of their use of their engineering degree, and reasons that influenced or may influence their decision to leave the position.

In the second and third sections of the survey, we ask participants to respond about their undergraduate experiences, current work experiences, and attitudes and beliefs about engineering. In terms of undergraduate experiences, we ask participants to select all engineering- and career-relevant experiences that they had, including internships, pre-professional organizations, and attending job fairs. Participants describe their current work experiences in terms of their developmental opportunities, turnover intentions, job attitudes, and support resources. These items, and several subsequent items about engineering attitudes and beliefs, are adapted from the POWER study [6], which investigated women's persistence in engineering careers. The POWER survey was derived from SCCT [10], which lends the ability to compare the proposed to previous literature. Although the POWER survey includes a measurement of engineering self-efficacy, in this study we operationalize a self-efficacy scale relating to the ABET student outcomes [25]. This tie between self-efficacy and accreditation student outcomes can offer insight into the actual tasks that engineering graduates use professionally. In addition to attitude and belief measures based in SCCT, we also include engineering beliefs factors related to participants' engineering identity (e.g., "I see myself as an engineer" [18]) and belongingness in engineering (e.g., "I feel comfortable in engineering" [26]).

In the fourth section, participants will identify key individuals and experiences encountered during their undergraduate program that were influential in forming the participants' career pathways. This information will be used to understand key resources that students may take advantage of to plan for the future. Finally, we collect information on participants' year of graduation, undergraduate major, gender, and race/ethnicity. In total, we approximate that the survey will take participants 10-15 minutes to complete.

Survey Development
The survey will be distributed to alumni in Summer 2019. Development and piloting will be conducted throughout Spring 2019. The survey was piloted with engineering graduates who attended universities other than the studied institution in order to gain evidence for the validity of the survey.

Analysis
The analysis will focus on descriptive and predictive strategies to understand the pathways of engineering graduates and certain factors that may be related to aspects of those pathways. First, the data will be analyzed to develop Sankey diagrams of graduates' pathways. Sankey diagrams are used in thermodynamics to visualize the flow of energy. In engineering education, the diagrams can represent change over time in participants' majors [27] or interest in engineering careers [28]. In this context, survey participants' career pathways will be categorized into major groups and arranged to show the development of pathways over time. Because the dataset contains alumni who have graduated recently and over 20 years ago, the diagram will be framed in terms of career positions (rather than years). Different Sankey diagrams will be generated to understand potential patterns in terms of gender or between different engineering majors.

Additionally, two regression models will be used to predict the relationship between participants' current careers and engineering. A logistic regression model will be used to predict the likelihood that a participant's perception that the position is related to engineering, while a linear regression model be used to predict participants' perceptions of using their engineering degree. These beliefs will be predicted through traditional measures of SCCT as well as through key experiences, identity, and belonging. Demographic information will be included in both models.

Expected Results
Like the Sankey diagram produced by Sadler and coauthors [28], we plan to create Sankey diagrams for men and women to understand descriptive differences in pathways. While the exact categories that are used to structure the Sankey diagram will be emergent from the data, we expect that the categories will fall into approximate categories of practicing engineer, engineering manager, sales, medicine, law, academia, and other.

We expect that beliefs about engineering task self-efficacy will be highly related to perceptions of doing engineering work, regardless of occupational title. We also believe that a sequential regression model will show that engineering belief measures predict a significant proportion of variance in perceptions of having jobs "related to" engineering, over and above SCCT variables.

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