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Paper ID #15657

Understanding Engineering Students' Professional Pathways: A Longitudinal Mixed-Methods Study

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Abstract

According to data from the National Science Foundation (NSF), nearly two-thirds of engineering bachelor's graduates work in engineering fields immediately after college, while another 30 percent takes jobs in non-engineering fields.[1] Prior work, however, shows that most engineering undergraduates are "unsure" about their future career direction, even in the months leading up to graduation,[2] and little is known about how and why they eventually choose what to do. Furthermore, while several college-related factors have been linked to engineering students' initial career decisions, how these and other factors actively shape their initial career steps remains understudied.

To address these gaps, we designed the NSF-funded Professional Engineering Pathways Study (PEPS), a three-year collaboration aimed at understanding and enhancing the process through which engineering undergraduates explore, select, and prepare for their chosen careers (NSF-EEC-1360665, 1360956, and 1360958). PEPS builds upon the rich tradition begun by two prior NSF-funded studies, the Academic Pathways Study (APS) and the Engineering Pathways Study (EPS), of using multi-institutional, mixed-methods research to delineate the experiences of engineering students and early career professionals. The project also features two components: the research component, and the community of practice component. The research component follows engineering students at six U.S. institutions through their junior or senior year, to examine how engineering students' career development and decision-making processes unfold over time. Also as part of this component, we are interviewing engineering faculty, student advisors, and career services staff about their perceptions of engineering students and the career resources provided to them on their campuses. The community of practice component focuses on bridging research-to-practice by engaging key stakeholders at the six partner institutions in data collection, interpretation, and dissemination activities. Outcomes from the study will include improving the career services and advising available to soon-to-be-degreed engineers at both these and other engineering schools.

Currently in Year 2, we are analyzing our information-gathering interviews with faculty, advisors, and staff and sharing our initial findings with stakeholders at each of our six partner institutions for their feedback. In addition, we are preparing to conduct longitudinal surveys and interviews of junior and senior engineering students during the upcoming 2016-2017 academic year. This paper summarizes the work completed over Years 1-2, and provides background and details about the project.

Motivation

The PEPS study follows a small, but growing, body of literature in engineering education on early engineering career choice. While some studies focus on the proportions of engineering bachelor's graduates who pursue engineering jobs and graduate degrees,[1,3] other studies have examined the specific factors related to engineering students having plans to pursue engineering careers, versus non-engineering careers, after college, finding that the experiences that

engineering students have in their programs have a big impact. For example, in their study of engineering undergraduates at nine institutions nationwide, Amelink and Creamer (2010) found that student satisfaction with the quality of teaching, the availability of role models, and the work load in their engineering program were all positively correlated with the intent to be working in an engineering field ten years in the future.[4] Likewise, Margolis and Kotys-Schwartz (2009) reported that mechanical engineering seniors at one western U.S. instruction were more likely to have plans to pursue – and stay in – an engineering career after graduation if they were satisfied with the quality of instruction in their program.[5] They were also more likely to intend to persist in engineering if they had positive senior capstone design or positive internship/co-op experiences.[5] In a study of engineering students at 31 institutions around the country, Ro (2011) found that the choice of pedagogy and curriculum within a program influences engineering student career decisions as well, with exposure to active/collaborative learning and both technical and professional engineering competencies related to having engineering (versus non-engineering) post-graduation plans.[6]

Results from our prior work, the Academic Pathways Study (APS) and the Engineering Pathway Study (EPS), have contributed to a better understanding of early engineering career choice as well. Sponsored by the NSF Center for the Advancement of Engineering Education (NSF-ESI-0227558), APS followed 160 engineering undergraduates from four institutions for four years using surveys and interviews for the purpose of studying the undergraduate engineering learning experience.[7] A cross-sectional survey was also administered to more than 4,000 undergraduate engineering students at 21 institutions.[8] EPS was a follow-up study that examined thirty-five of the original APS participants 4-5 years into their careers using a questionnaire and interview (NSF-DUE-1020678, 1021893, 1022024, 1022090, and 1022644). EPS also included a survey of 500 engineering alumni four years after earning their engineering bachelor's degrees from four APS institutions.[9] Findings from APS indicate that while 28 percent of engineering juniors and seniors have engineering focused plans for after college, and another seven percent have non-engineering focused plans, the vast majority of this group – 65 percent – remain open to a wide range of career options, including both engineering and non-engineering work and/or graduate school.[10-11] Findings from EPS show that 80 percent of engineering graduates eventually go on to accept a first position in an engineering field.[12] APS and EPS have also identified factors related to both engineering students' post-graduation plans and early career engineering graduates' choice of position; these include choice of undergraduate institution and major, choice of engineering and non-engineering curricular and extracurricular activities, and other, non-school related factors such as family and job market considerations.[10-13]

A drawback to the foregoing studies (including APS and EPS) has been that they each look at only one side of the college-career trajectory, either before graduation (APS) or after graduation (EPS), providing limited view into what plans engineering undergraduates actually implement upon graduation, and whether these plans meet the expectations they had as students.[11] This is addressed in the PEPS study, as its focus is following engineering students at six institutions through their junior or senior year. In this way, we are able to investigate how these students' career plans unfold and which factors become more or less salient to their career decisions as they approach graduation. We wish to find out, for example, how students' knowledge and interest in careers develop, and how career knowledge and interest influence their career plans and perceptions of career preparedness. Recognizing that research alone seldom drives change,

PEPS also aims to bridge research-to-practice. Our specific goal is to engage key stakeholders at our partner institutions in using results from our research to improve engineering career services and advising on their campuses.

Study Design

PEPS features two critical and interconnectedness components: the research component, focused on furthering understanding of early engineering career choices, and the community of practice component, committed to reviewing the data generated by the research component and identifying ways in which the findings can be used to improve educational practice. Each component is grounded in its own framework, questions, and methods, described below.

Research Component

The Professional Pathways Model shown in Figure 1 guides the research component of this project. We developed the Professional Pathways Model by combining cognitive information processing (CIP) theory[14] and expectancy value theory (EVT).[15] According to CIP theory, individuals need two types of knowledge to make career decisions, knowledge about what career options exist and knowledge about one's own skills, values, and interests, etc. EVT explains how this knowledge is developed (e.g., through past experiences, family influences, and cultural factors) and how it motivates individuals' career choices (i.e., through expectancies and values). Both CIP theory and EVT have been used to study engineering students with good results.[16,17,18] Together, they provide a comprehensive framework for understanding how engineering students' beliefs about their career options and themselves influence their decision-making.

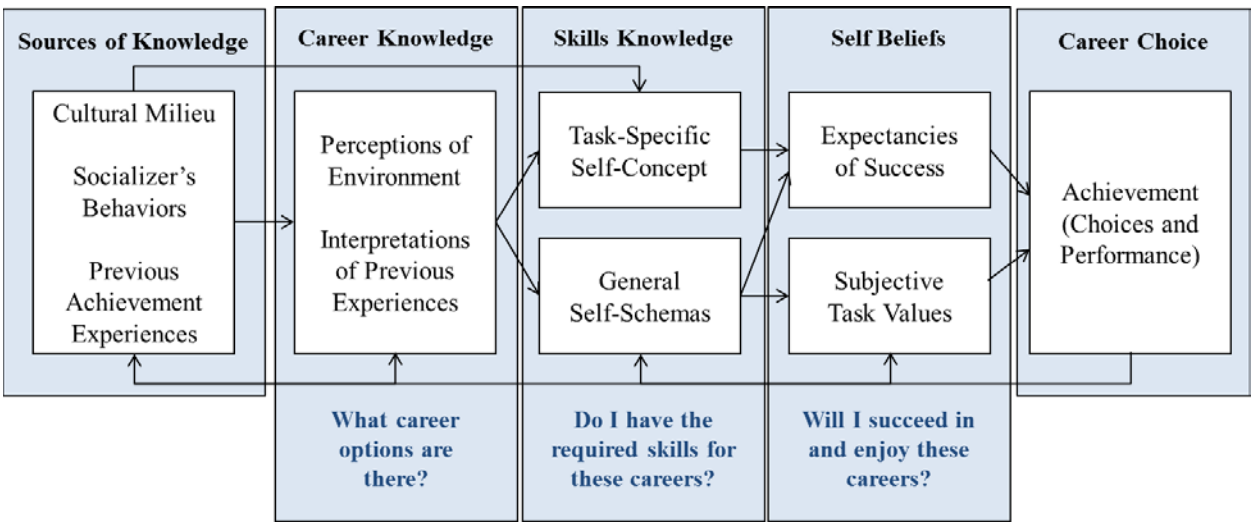

Figure 1: Professional Pathways Model: Expectancy Value Theory overlaid with Cognitive Information Processing Theory (in bold), as taken from Brunhaver et al. (2015)[19]

The Professional Pathways Model suggests three sets of questions for investigation in our study:

- Career Knowledge: What career options do engineering students believe are available to them? How do students develop knowledge of these options?

- Self Knowledge: What skills and abilities do students believe they need to find, obtain, and succeed in a career? How do students develop knowledge and proficiency in these skills and abilities?
- Career Decision Making: What career goals, expectancies, and values do engineering students have? How do these develop and change over time? What career choices do engineering students make for after graduation, and what role(s) does their career and self knowledge play in their decisions?

We are using a multi-method approach to answer our research questions. We have already interviewed engineering faculty, student advisors, and career services staff at our six partner institutions, to help us understand (1) the career resources available to engineering students on these campuses, (2) the career pathways that these engineering students typically take, and (3) the skills and abilities they believe students need to find, obtain, and succeed in these pathways as graduates. Findings from these interviews are helping to inform a one-year longitudinal study focused on engineering juniors and seniors. Using longitudinal surveys and interviews, we will follow engineering juniors and seniors at each of our partner schools, from the beginning of the 2016-2017 academic year, to the end. The result will be a qualitatively rich and quantitatively broad data set that captures both sides of the engineering college-career transition (i.e., students' career planning as they approach graduation, and the career decisions they make immediately after), as well as changes in engineering students' career decision-making over time.

Community of Practice Component

In conjunction with our research effort, this study utilizes a community of practice framework to implement research-to-practice and share our project results. Wenger et al. (2002) define a community of practice as a group of people who share an interest and practice in a particular domain.[20] In our context, the community is comprised of key stakeholders at each of our partner institutions (e.g., heads of career services, associate deans of engineering), the domain is the career preparation of engineering students, and the practice is using results from our research component to strengthen career services and advising. Findings from the research will be shared with this community regularly, both to inform its practice and collect feedback. We expect that the community will help shape future directions of the project by reacting to the data and helping us see what resonates with them, what surprises them, and what they think is important for additional data collection. We also anticipate that, through working with these stakeholders, we will uncover best practices for community building and dissemination.

Partner Schools and Participants

This study takes a national perspective, drawing on data from six partner institutions across the United States. Because a specific aim of the study was to explore the similarities and differences in engineering students' career decision-making by institution, each school was selected for its institutional and student diversity, as determined by the Carnegie Classifications[21] and the American Society for Engineering Education (ASEE) College Profiles data.[22] Our sample therefore includes a mix of public and private schools, doctoral and master's schools, and schools focused on liberal arts versus schools focused on the professions. We also have a mix of predominantly white universities (PWIs) and schools that serve historically underrepresented

groups. In addition, we have two schools each from three different U.S. regions – the West Coast, the Midwest, and the East Coast, broadly – to help differentiate the effects of regional differences from institutional differences. For example, the types and amounts of industry surrounding each pair of schools vary. The regions were selected based on where the PI team had existing relationships and background knowledge.

Our six partner schools awarded approximately four thousand undergraduate engineering degrees in 2015.[22] Based on this number and our response rates to the APS and EPS surveys (approximately 20 percent),[23-24] we expect that at least 1,600 engineering students will participate in our study.

Major Activities in Years 1-2

Interviews with faculty, advisors, and staff were completed at each of our partner institutions in Year 1. Over thirty participants were interviewed in total, including 15 individuals from career services (13 from university career services, two from engineering career services), eight engineering student advisors, and nine engineering faculty members. Participants were selected based on recommendations from our partner school liaisons, content analyses of each school's career services websites, and the PI team's own networks. Moreover, the engineering student advisors and faculty members we interviewed came from three different engineering disciplines: mechanical engineering (ME), electrical engineering (EE), and bio-X engineering (Bio-E). These disciplines were selected because students in these fields tend to pursue unique career pathways relative to other engineering students, with ME majors the most likely to pursue engineering careers, EE majors the most likely to pursue other STEM (e.g., computer science) careers, and Bio-E majors the most likely to pursue non-STEM engineering careers.[10-12]

All interviews with faculty, advisors, and staff were audio recorded, transcribed, and analyzed using common qualitative coding approaches.[25-26] Findings from two schools, Midwestern Private University and Western Private University, revealed that while career services staff believed that engineering students have the skills and abilities required to succeed in an engineering career, some may not necessarily have the skills and abilities to acquire a job offer solely from their engineering curriculum. These findings were submitted to the Educational Research Methods Division of the 2016 ASEE Annual Conference. A journal article summarizing results from the full range of schools is in progress. Future analysis will focus on related topics, such as differences in the career services and advising offered at each institution and how these differences impact students. For example, while some sites proactively reach out to students (e.g., with required courses or advising meetings, intensive advertising campaigns), other sites engage with students only once the students request help.

Now in Year 2, the team has been meeting individually with our partner school liaisons and other key stakeholders. Part of these meetings has been used to present results from our qualitative analyses, as well as our work-in-progress paper presented at the 2015 Frontiers in Engineering Conference.[19] Another part has been to solicit feedback on the development of our longitudinal study of engineering juniors and seniors across our partner schools. This has involved developing survey and interview protocols based on the Professional Pathways Model, our interviews with faculty, advisors, and staff, and other existing work such as APS and EPS. Next, the survey and

interview protocols will be evaluated for face validity through expert review, before being piloted with engineering students at other institutions. The final survey and interview protocols will be deployed at our six partner schools during the 2016-2017 academic year. An initial survey and interviews of engineering juniors and seniors in the fall and winter will be followed by a second survey and interviews of the same individuals in the spring and summer.

Plans for Future Activities

Deployment of the first student survey in Fall 2016 will be followed by the first round of student interviews in Winter 2017. We will select at least 10 students from each partner school (for a total of 60 students) to participate in an in-depth, semi-structured interview based on their demographic characteristics and baseline survey responses. We are particularly interested in capturing the stories of underrepresented students (i.e., underrepresented racial/ethnic minorities, women, transfer students, etc.) for which our institutional sample is well-poised, and of students from the three majors this study is targeting (ME, EE, and Bio-E). A follow-up survey and interview will take place in Spring and Summer 2017, respectively. We expect the data collected to serve as the basis for several publications, including an article comparing the perceptions that faculty, advisors, and staff have of student preparedness with the perceptions that students have themselves, as well as an article tracking changes in students' career decision-making over time.

Findings from the surveys and interviews will also be shared with the stakeholders we have identified at each partner site as key to engineering career services and advising (e.g., the heads of career services, our partner liaisons). We will seek help from these stakeholders with interpreting, disseminating, and making changes within their institutions based on these data. After working to establish these partnerships locally in Year 2, we will turn our attention outward to building a community of practice across schools in Year 3. A symposium for Fall 2016 where stakeholders can meet and discuss the impact that the results of the project have been having on their specific campuses is being planned. The last year of the project will also focus on broader dissemination of our work to the engineering education and career development communities. Specifically, we will be able to share best practices for supporting engineering students' career development, as well as a model for using longitudinal data to drive continuous improvement within engineering programs.

Acknowledgements

We would like to acknowledge the larger PEPS research team, including Amy Engelman, Helen Chen, Shannon Gilmartin, Gary Lichtenstein, and George Toye. We also thank our study participants and partner school liaisons for their time. This research is funded by the NSF as a collaborative research grant (EEC-1360665, 1360956, and 1360958). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

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