New Orleans JAZZED about Engineering Education

What Do You Want to Do with Your Life? Insights into how Engineering Students Think about their Future Career Plans

Michelle Marie Grau, Stanford University

Michelle Grau is a K-12 Design Thinking, Engineering, and Robotics teacher at The Nueva School, where she primarily teaches in the middle school and coaches robotics teams (FIRST Lego League and FIRST Robotics Competition). She started research in engineering education as an undergraduate mechanical engineering student at Stanford in Dr. Sheri Sheppard's Designing Education Lab in 2011, where she continues that work today.

Dr. Shannon Katherine Gilmartin, Stanford University

Beth Rieken, Stanford University

Beth Rieken is a sixth year graduate student at Stanford University. She is currently working on her PhD in Mechanical Engineering with a focus on the relevance of mindfulness to engineers. Beth completed a BS in Aerospace Engineering from the University of Virginia in 2010 and a MS in Mechanical Engineering from Stanford in 2012.

Dr. Sheri Sheppard, Stanford University

Sheri D. Sheppard, Ph.D., P.E., is professor of Mechanical Engineering at Stanford University. Besides teaching both undergraduate and graduate design and education related classes at Stanford University, she conducts research on engineering education and work-practices, and applied finite element analysis. From 1999-2008 she served as a Senior Scholar at the Carnegie Foundation for the Advancement of Teaching, leading the Foundation's engineering study (as reported in Educating Engineers: Designing for the Future of the Field). In addition, in 2011 Dr. Sheppard was named as co-PI of a national NSF innovation center (Epicenter), and leads an NSF program at Stanford on summer research experiences for high school teachers. Her industry experiences includes engineering positions at Detroit's "Big Three:" Ford Motor Company, General Motors Corporation, and Chrysler Corporation.

At Stanford she has served a chair of the faculty senate, and recently served as Associate Vice Provost for Graduate Education.

What Do You Want to Do with Your Life? Insights into how Engineering Students Think about their Future Career Plans

Abstract

This research paper describes findings from a qualitative analysis of engineering students' self-reported future career plans on the 2015 Engineering Majors Survey (EMS). The EMS was designed to examine current engineering students' career goals, especially surrounding innovative work, and is based in the theoretical framework of Social Cognitive Career Theory (SCCT). With the open-ended responses on the EMS, we can develop a deeper understanding of students' plans in their own words, providing insights into *how* they think about their careers and *why* they want to go down a particular career path. The primary research questions for the present study are:

1.   What are the different ways students think about their future plans?
2.   What are the motivations that drive students to choose a particular path?
3.   Are there significant differences between how men and women think about their futures?

The EMS survey was sent to engineering juniors and seniors at 27 schools in the spring of 2015; a total of 7,197 students participated. Included on the questionnaire was the open-ended question, "We have asked a number of questions about your future plans. If you would like to elaborate on what you are planning to do, in the next five years or beyond, please do so here", which elicited 1,848 responses. Responses were varied, and were coded by emergent themes. Ten main emergent themes were identified; examples include whether or not they intended to stay in engineering after graduation, mention of the industry they intended or would like to go into, and explanation of their motivations.

Findings point to three main ways that students think about their career plans: by identifying a specific company they want to work for, by identifying a specific industry they want to work for, and by seeking a job with a certain trait. Students' motivations included wanting to help people, a desire to combine engineering with another field, an inherent love of doing engineering, and doing engineering as a means to a secure future. Some motivations varied by gender: men were more likely to discuss a desire to travel, while women more often considered childbearing and family factors in their career plans.

These findings have several implications for educational research and practice in engineering. Understanding more about students' motivations helps researchers and practitioners to think more comprehensively about the persistence of different students in engineering post-graduation. Our findings suggest that some students might plan to leave engineering because of wanting to go to medical school, start a family, work for a non-profit, or become a teacher - not because

they do not enjoy engineering. These insights can help engineering educators at all levels as they strive to make content relevant and meaningful to their students, ideally helping students connect what they are learning to their future goals. This information also can lead to recommendations for future survey questions that more fully capture the range of students' actual perceptions, worries, hopes, and plans about their futures.

Introduction

The National Center for Engineering Pathways to Innovation (Epicenter) was launched in 2011 on the premise that it is becoming more necessary for engineering students to learn skills relating to innovation and entrepreneurship (I&E). The work of Epicenter aims to strengthen entrepreneurship education for engineers and expand understanding of how I&E learning environments influence students. As part of the Epicenter research projects collectively known as Fostering Innovative Generations Studies (FIGS), the Engineering Majors Survey (EMS) was created and administered in Winter/Spring 2015. The EMS was designed to examine current engineering students' career goals, particularly surrounding innovative work. This survey is based in the theoretical framework of Social Cognitive Career Theory (SCCT)[1], which describes how a variety of individual and contextual factors may affect career choices.

To date, one piece missing from current knowledge about engineering students' career goals and pathways is a deep understanding of students' plans in their own words, providing insights into *how* they think about their careers and *why* they want to go down a particular career path. This research paper describes the findings from a qualitative analysis of EMS survey responses to an open-ended question about future career plans. The primary research questions for this study are:
   1) What are the different ways students think about their future plans?
   2) What are the motivations that drive students to choose a particular path?
   3) Are there significant differences between how men and women think about their futures?

Literature Review

Previous research has taken a broad and largely quantitative view of engineering students' career plans and pathways. Drawing from the Academic Pathways of People Learning Engineering Survey (APPLES) data, Sheppard, Antonio, Brunhaver, and Gilmartin[2] found that nearly one-third of engineering juniors and seniors in this sample were exclusively focused on engineering options (jobs or graduate school) when thinking about their post-graduation pathways, and less than ten percent were exclusively focused on non-engineering options. The majority of engineering students, in other words, were considering both engineering and non-engineering options in their future, and/or were uncertain about what was ahead.

Sheppard et al.[2] also analyzed nationally representative employment data for engineering graduates approximately two years after earning their undergraduate degree. These data, which source from the National Survey of Recent College Graduates (NSRCG), indicated that 60 percent of new engineers were employed in engineering jobs, 18 percent were employed in a related field, 14 percent were employed in a field unrelated to engineering and science, and the balance were students or unemployed. Graduates from civil engineering disciplines were most likely to be working in the same field as their undergraduate major. Graduates from electrical engineering were least likely to be doing so.

Career thinking may be different for women and men, as students or as early career professionals. In the APPLES data[2], men were more likely than were women to have engineering-focused post-graduation plans; similarly, in the NSRCG data, men were more likely than were women to be employed in engineering jobs two years after graduation. Another study about freshmen students' motivations[3] showed significant differences between both men and women engineering students, and engineering versus non-engineering women. Their results suggest that engineering women tend to have more extreme career motivations than men, indicating that engineering is attracting women who are willing to sacrifice other aspects of their life for their careers.

In further quantitative-based exploration of engineering students' early careers, the Pathways of Engineering Alumni Research Survey (PEARS) was administered in 2011 to engineering graduates of the class of 2007 at four U.S. institutions; this was part of a larger project called the Engineering Pathways Study (EPS). The goals of this project were to identify the educational and workplace factors that influenced engineering graduates' initial and future career plans, and to develop a better understanding of their early career work. Drawing from the PEARS data, Brunhaver[4] showed that engineering graduates who were non-engineering focused four years after earning their degree were different from their engineering focused peers in terms of certain undergraduate experiences (e.g., they were less likely to have participated in an internship or co-op) and level of technical interests. Moreover, while women and men graduates in this sample were not different in terms of their current position (engineering or non-engineering), they were different in terms of future plans. Women tended to have lower technical self-efficacy and interests than did men, which helped to explain why they were more non-engineering focused in their plans.

Qualitative analyses of engineering students' career thinking indicate that early career goals are often influenced by a desire to find interesting work[5]. A related study examined how engineering students see the importance of certain skills to their careers and how this perceived importance changes over time. In this study, business skills were consistently perceived to be least important, while communication skills and the ability to apply math and science were perceived to be most important[6]. Students' motivational values have been studied using qualitative methods

as well; for instance, Matusovich, Streveler, and Miller[7] identified four main values, including "interest" and "utility", that led to students persisting in engineering majors.

However, these qualitative studies do not examine the general ways that students think about their future careers and had a small number of participants. This current project builds on this work, but also fills an important gap by qualitatively examining a much larger and older participant group, and explores the different lenses through which students appear to think about their careers, including persistence in engineering, wanting a job with a certain characteristic, and driving motivations.

Findings from this study also can help to inform quantitative SCCT models of the EMS (and other survey) data. Broadly, SCCT stipulates that career goals are a function of interests, and interests are influenced by self-efficacy in performing tasks relevant to the goal, expectations for the outcome of these tasks, and learning experiences[1]. The data in this study, based on answers to an open-ended question, help to describe students' interests with greater specificity than what can be gleaned from the fixed-choice questions on the survey, thus bringing more detail to bear on the relationships between interests and goals. In addition, the data in this study shine a light on particularly relevant learning experiences and motivations that might not be represented in models of career goals, leading to ideas for future research.

Methods

The Engineering Majors Survey was emailed to engineering students at 27 institutions in the winter/spring of 2015, and gathered 7,197 responses. The 27 institutions were chosen to represent the larger national population of institutions with engineering schools in terms of type, size, and presence of an undergraduate business major. The design of the EMS took place over a seven-month period in 2014-15, and included three pilot administrations to engineering students at non-study institutions in order to develop comprehensible and valid measures. The final instrument includes 35 questions covering five different sections: Current Plan of Study, School Experiences, Beliefs, Expectations, and Interests, Future Career Goals, and Background[8]. Extensive psychometric analyses of constructs on the instrument are underway at the time of this writing (thus far, each construct shows a high degree of reliability).

This paper focuses on a qualitative analysis of an open-ended response prompt at the end of the survey, **"We have asked a number of questions about your future plans. If you would like to elaborate on what you are planning to do, in the next five years or beyond, please do so here."** There were 1,848 responses to this question, which represents 26 percent of total respondents. Table 1 shows the breakdown of these respondents by year in school. In addressing our third research question on gender differences in our data, we note that women provided 30 percent of responses, which matches the proportion of women among all survey respondents.

Since the survey was primarily targeted to juniors and seniors, they made up the majority of the respondents to this question.

Table 1: Respondents to open-ended question by year in school (n=1,848)

Year in School	n	%
Freshman	30	1.6
Sophomore	164	8.9
Junior	668	36.1
Senior	767	41.5
5th-year Senior	216	11.7
Other	3	0.2

Responses were extremely varied, and were coded by emergent themes[9], as presented in Table 2. Ten main emergent themes were identified, and further in-depth analysis then took place for several categories, where they were broken down to more specific subcodes and recoded to capture more insights. For themes with multiple subcodes, tables are provided to show the frequency of each sub-code and sample quotations. For themes with no sub-codes, sample quotations are presented in text. A single response (i.e., comments from a single student) could have as many codes as were applicable. For example, a person indicating they already had an engineering position at a specific company would have three different tags: "clarity of plans - knew exactly", "Engineering involved in plans - Yes", and "Specific company". The same rationale applies to sub-codes; one response could have multiple sub-codes. For example, a person indicating they wished to work at a large company where their job would involve traveling would receive two "Job trait" sub-codes: "Size of company" and "Involves travel".

As coding qualitative data is an iterative process, the themes and codes were often discussed within the research team and modified accordingly. In several instances, questions came up that resulted in creating new sub-codes. For example, the first pass of coding for "Engineering involved in plans" only had "Yes", "No", and "Don't know". The question arose of what to do with respondents who indicated they planned to do engineering for a time and then leave engineering. Initially these respondents were tagged as "Yes", but that was not accurately capturing the entirety of what they were saying therefore the team created a new sub-code, "Engineering then leave".

In addition to probing the coded responses for how students think about their careers and why they want to go down a particular path, the research team also analyzed the responses by gender.

The gender breakdown of responses in each category provided a way to scan for any over- or under-representation of female responses.

Table 2: Themes and codes for qualitative analysis of open-ended responses

Code	Explanation
Overall Plan	
Clarity of plans *Sub-codes: No idea, Some idea, Knew exactly*	This theme describes how clearly-formulated respondents' ideas for their futures were.
Engineering involved in plans *Sub-codes: No, Yes, Don't know, Probably, No indication, Engineering then leave*	This theme describes if the respondent plans to be involved in engineering in the future.
Career Characteristics	
Specific company	This theme indicates respondents who mentioned a specific company, in any context (will be working at, want to work at, or want to work at a company like this one).
Industry	This theme indicates respondents who mentioned an industry, in any context (will be working in or want to work in).
Job trait *Sub-codes: Size of company, Type of company, Involves travel, Trait of the work, Location, Trait of the company, Employer pays for further education*	This theme describes traits that a respondent may be looking for in a job or company besides simply what industry the company is in.
Start business	This theme indicates respondents who mentioned anything about starting a business (will be starting one or have an interest in starting one).
Management	This theme indicates respondents who mentioned an interest in management.
Teaching	This theme indicates respondents who mentioned teaching in any capacity.
Life outside career *Sub-codes: Family/kids, Traveling*	This theme describes respondents' thoughts about future plans besides their thoughts about their careers.
Career Motivations	
Motivation *Sub-codes: Giving back/helping people, End goal for their life, Work for specific company, Desire to combine engineering with another field, Inherent love of engineering work, Secure future, Other*	This theme describes explanations for why respondents plan to do what they want to do.

Results and Discussion

Research Question #1: What are the different ways students think about their future plans?

Many of the emergent themes in our data relate to *how* respondents think about their future career aspirations. These themes range from general ideas about the involvement of engineering in their future career to indications of whether or not a certain aspect (e.g., management, teaching) is part of their plan. The findings are organized into the following categories: students' overall plans; different ways they think about their future careers; prominent roles that students mentioned; and students' ideas about life outside of a career.

Overall Plans

Clarity of plans

All responses were coded according to the clarity of future plans, i.e., if the student had an idea of what they wanted to do upon graduation. Table 3 shows the "Clarity of Plans" sub-codes, the percent of the respondents in each sub-code, and excerpts from example responses. Perhaps unsurprisingly, the majority of the people who did not know what they wanted to do were freshmen, sophomores, and juniors, while the senior students had the clearest sense of what they wanted to do or had concrete plans. However, it is interesting to note that some people who really did not know what they planned to do after graduation still opted to write about it.

Table 3: Data for "Clarity of Plans" (n = 1790)

Sub-code	%	Example Responses
No Idea	15	"I have no clue what the future beholds after school." "I plan to be flexible and evaluate my opportunities as they present themselves"
Some Idea	34	"I'd like to explore the field of green product development to lead the move towards more sustainable solutions to our daily lives" "I would like to work in a firm that allows me to move/know different places and where I get to be part in projects with other engineers. I would also like to later on, own my own construction company."
Know Exactly	51	"I will be working wind farm project development for a developer, then transitioning into a career in policy or government affairs with a wind energy developer." "Go to grad school to be an oceanographer." "I am joining a large engineering firm doing Structural Engineering in the Aviation and Global Facilities industry."

Engineering Involved in Plans

The majority of student respondents indicated that they would remain in the engineering field, i.e.,70 percent intended to go into engineering after graduation, which is consistent with the literature on engineers' *destinations* two years after graduation (but is higher than is the percentage of engineering students who are exclusively *planning* on engineering options when they graduate)[2]. However, others knew that they definitely did not want to be an engineer, and some were not sure if they wanted to use their engineering education. As seen in Table 4, these responses offer insights into why some engineering students do not continue into the engineering workforce upon graduation. Very few respondents indicated a dislike of engineering directly, instead indicating that they had other plans, such as joining the military, going into a non-engineering school program, or exploring another interest. One set of respondents was vague (e.g., "Get a job"), which was interpreted to mean that the student most likely was considering engineering. Another group of respondents simply gave no indication about whether their plans involved engineering or not. Lastly, there were students who wrote that they planned to work as an engineer for a time, and then transition out of engineering into something else. These respondents are included in the "yes" category, because they are planning to go into engineering first, and were also tagged with the "engineering then leave" sub-code. Two main themes within the "engineering then leave" sub-code emerged: doing an engineering job to earn enough money to be able to do something else, and having multiple interests and wanting to pursue something else eventually.

Table 4: Data for "Engineering involved in plans" (n =1663)

Sub-code	%	Example Responses
No	6	"After finishing my biomedical engineering degree, I plan on going to medical school. I loved the idea of having an engineering degree as a back up plan and also because I found the material very interesting." "I want to got law School and while there obtain an MS in History"
Yes	70	"Currently not sure, but hoping to use my engineering degree to work with people in a medical field setting." "work, employer pays for MS, Go live and work abroad, attain PE, become senior engineer status, at this point make bank like a boss"
Don't know	12	"Travel and/or live abroad, and hopefully but not necessarily work in engineering" "Go to medical school, if not get my Masters and PhD in either electrical or biomedical engineering and work for the DOD"
Probably (vague answer)	9	"Get a job, get financially stable, go on vacation." "I am hoping to be hired into a company that has a position that draws in my imagination and attention. I do not necessarily know what this looks like but I will know it when I see it."
No indication	3	"Hope to travel/work for non profit in the first year or two after I graduate" "Currently undecided but will be looking to work abroad at some point."
Engineering then leave	3	"Engineering, engineering management, or start directly in engineering management. Eventual goal is real estate and public office in Texas (or California if I were from the state)." "I am just focused on getting a decent job right out of college. Engineering should open up a lot of possibilities for a job. If satisfied financially, I would like to go back to school and pursue a degree that suits me better."

Different Ways Students Think about Careers

Engineering students appear to think about their future career plans in many different ways, though three main categories were identified: wanting to work for a specific company, wanting to go into a certain industry, or wanting to find a job with a certain trait.

Specific Company
Approximately 15 percent of the total respondents mentioned a specific company in their answer. Within the "Specific company" category, there were several themes. As Table 5 shows, the majority of the responses in the "Specific company" category indicated that the student had already accepted a job at a company, or had definite plans (for example, going into a branch of the military). The remainder primarily either indicated their desire to work at a specific company, or referenced a specific company as an example of a place that they would like to work. In some

cases, it is evident that internships played a key role in the desire to work at a specific company, with many respondents planning to return to a specific company where they previously completed an internship. In a handful cases the student indicated that working for a specific company was the most important thing above all else; they did not care about the work they were doing, so long as it was for that particular company.

Table 5: Data for "Specific company" (n = 268)

Themes	Example Responses
Already accepted a job	"After graduation, I will be working for Oscar-Mayer research and development in a process engineering position." "I have accepted a job with GM, I will most likely work there for 3 years"
Want to work at a specific company	"My goal is to get a position with the DOE as a research scientist." "I hope to work for the government and get my Masters in Computer Engineering and PhD in Aerospace (in hopes of working with NASA) and do a lot of work in robotics."
Previous Internship	"I expect that I hire on after my current internship and will be working in the science division of Monsanto. I plan to gradually shift my career toward the corporate side of research management as I gain experience, eventually going back to school for either a PhD or an MBA (hopefully partially funded by the company) to become more competitive." "I have an internship doing Technology Consulting at Accenture and hope to work there after graduation."
Reference specific company as an example	"I'd like to work for a private space company, such as SpaceX, Boeing, etc." "I'd like to work at a large company (think Google) for the next five or so years, and then start my company after that (once I've made some money.)"

Industry

Approximately 18 percent of total respondents mentioned a specific industry in their response, though through several different contexts as shown in Table 6. These respondents tended to be more uncertain about what they would like to do, mostly indicating a general industry path they hoped to work in based on current interests. In some cases, it overlapped with a motivation, with students explaining why they wanted to go into a specific industry; here the impact of specific classes or experiences sometimes contributed to the respondent's desire to go into that industry.

Table 6: Data for "Industry" (n = 328)

Theme	Example Responses
General industry	"I really want to work in the automobile industry." "I would like to take my engineering skills as well as my interest in the food industry to either starting or getting involved with a brewery or other major company in the food and beverage industry."
Motivation	"I would like to work in the prosthetic limb industry. I would like to work with a company that improves the design and efficiency of this technology. It is something that I am very passionate about, and would like to expand my learning in that subject." "Well, I currently work in a software development position, and I intend to continue it after graduating. However, after that the future is open... my true passion is games, so I may go on to work at a game design company, but I could also go into game journalism, streaming, professional gaming (Magic The Gathering) or start working for Wizards of the Coast in some fashion."
Influenced by specific experience	"Energy interests me. As a group project in a class, we built a wind turbine.. Loved it.. Both the greater ideas that it stood for in terms of green energy and seeing something that myself and a couple classmates created from scratch actually work. Have not taken any ChemE specific courses yet and would probably be able to answer a lot of these questions more accurately in a couple semesters. As of now, I find the possibilities of natural gas intriguing and believe that a ChemE degree would provide opportunity to work in that field."

Job Trait

Approximately 11 percent of respondents mentioned job traits. These responses were sub-coded to gain further insight, as shown in Table 7. Mentioning the size of the company was the most common among the job trait responses, with many respondents indicating a preference for a certain size (small, medium, or large), while others indicated what they thought was likely to happen if they ended up a certain size company. Another prevalent theme is mention of a "trait of the work" the respondent was looking for, such as a job that involves using a specific skill. These respondents appear to care about what they would be doing, rather than where they are doing it. In contrast, some people mentioned a trait of the company they wanted to work for, such as a company focused on making a difference in the world. These people appear to care about the kind of company they work for, and not as much about the kind of work they would be doing.

Table 7: Data for "Job Trait" (n =196)

Sub-code	%	Example Response
Size of company	41	"Most likely work for a larger company at first. Although I'd like to work for smaller companies since I don't like large corporations and the atmosphere." "First to [get master's degree], then to take a 6 month break to travel the world and backpack around in asia and europe, and then start to work in a medium to large size company."
Type of company (public/private, non-profit)	6	"Work for a private engineering firm" "I need a job to pay off debt. I will probably just be a code monkey for a while. Hopefully I will eventually become a developer for an open source software project and be paid through a nonprofit foundation."
Involves travel	5	"I plan to work for a company that welcomes students who are eager to learn what makes the company tick and to keep the bad guys out and the good stuff in. (Netops/System security) Preferably an international-presence company as I enjoy traveling." "Work as an engineer for a company with opportunities abroad"
Trait of the work	22	"Find a job involved in design engineering (using Solidworks or other similar 3D modeling software) or manufacturing" "I plan to work anywhere I can use both my love of science and engineering as well as my love of foreign language. Preferably in a hands-on technical environment where I have the opportunity to work with the technical processes as well as interact with many different people."
Location	8	"I am not yet certain as to what field of engineering I would like to get into at this point, however I would like to find a job in the central Texas area. Preferably somewhere between San Antonio and Austin." "I want to go back to Seattle because location is most important to me. Then I plan to look for a job in for a medical device company, probably small, in the area. If that fails I will try to work at Boeing. And if that fails I'll likely go to graduate school to help my chances."
Trait of the company	17	"I would like to work for companies with a focus on societal impact in a positive way, and hopefully transition at some point to being an educator in either a K-12 system or at a university." "I would like to pursue a master in Alternative of Renewable Engineering. With that I would like to pursue a job at a company that has a mission with a long term focus on being sustainable. I would like to work for a company that has the long term in mind, and not just quarterly profits."
Employer pays for further education	9	"Best case scenario would be to get a job that will pay for me to get a Master's or Doctorate, then eventually start my own business." "I plan to go into industry after i graduate with hopes of finding a job that will pay for my masters degree."

Prominent Career Roles

In addition to different ways that students think about their careers, there were three commonly mentioned roles people were interested in having at some point: starting a business, management, and teaching. All three were most commonly mentioned as something the student wanted to do *later* in their career, giving a lens into what they were thinking about not just in the immediate future, but further out.

Start Business
Thirteen percent of students (n=239) mentioned the idea of starting a business in their answer. The majority of them were vague, indicating a generic interest in potentially starting a business. The focus of the full EMS survey was on innovation and entrepreneurship, which could have influenced the mention of starting a business in the open-ended responses. Some students indicated that starting a business was something they wanted to do at some point in their life, but likely down the road (often indicating they would work in industry for a time before starting a business). A few had already started a business, and indicated they would like to keep working on it. Example responses are included below:

"I started my company last summer, and I will keep working on that business."

"Not exactly sure. I would love to start my own business. I have a lot of ideas, but I am not sure where to start, or if I even have the balls for it."

"I plan to get a job at a company that will pay for grad school, get an MBA, and then start my own company."

"Graduate and find a job that can provide funds while I work to start up my own business."

Management
Seven percent of students (n=124) mentioned management in the description of their career plans. The majority of students imagine being an engineer for a time, and then moving into management; however people mentioned different reasons for wanting to go into management. Some people are interested in management and want to move that direction, others believe they will be better suited to management than engineering, and others have perceptions about the traits of a management job (for example, it will involve less travel). Example responses are included below:

"I plan to get a job as a controls engineer. From there I plan to gain a reputation with my company and move around in various roles in my organization. Eventually I would like to move into management which will lower my traveling (as I would like to start a family and be home more with my significant other)."

"Become a well-established project manager for a top construction firm"

"I would like to enter the engineering field in some form of design work. After five to ten years, I expect to move from design into management. However, I have been offered more engineering management opportunities than those for design. I might end up there instead as it seems to be more suited to my demeanor and skill set."

"I plan on definitely getting my MBA. I think I also have an interest in joining management."

Teaching

Five percent of respondents (n = 90) mentioned teaching in their answers. Similar to management, it was most commonly mentioned in the context of doing engineering for a time and then moving into education. Example responses are included below:

"I love my field and I love engineering, but if career paths or career changes later on down the road are complicated I would actually love to wind up as a teacher later on in life."

"I plan to work first either as a teacher or as an engineer. Then enroll in a PhD Program in STEM/Engineering Education and eventually start my own STEM-focused K-12 school."

"I plan on getting my MS in Materials Science and Engineering and possibly my PhD. Then I want to work with the development of 3D printers. Eventually I think I want to become a professor and run my own research lab."

"Right now my hope is to go to medical school but there is an engineering job that I'm looking at taking if I end up needing to take a gap year. If I never get into medical school...I'd secretly like to be a high school teacher."

Considerations beyond the career

Life Outside Career

Three percent of students (n = 57) mentioned something outside of their career plans. Most of these responses were about having a family, especially plans around having kids. Travel was another theme, along with things they knew they wanted do in their free time. Example responses are included below:

"get a Dog , Wife , Car , and a cool house :P"

"Eventually have kids and stay home with them. Then maybe go back to work."

"I'd like to either become a patent attorney after graduation or go into industry and in my free time manufacture prosthetics for children and/or animals in need using technologies like a 3D printer."

"I would like to travel after I graduate, probably a cross-country trip."

"Work, mentor robotics, teach flute"

Summary

Approximately half of the respondents knew what they wanted to do upon graduation. Seventy percent of the respondents planned to stay in engineering in the immediate future. Students appear to think about their future careers in three different ways: working for a specific company, working in an industry, or by wanting a job with a specific trait. Starting a business, being a manager, or being a teacher were three roles mentioned often in the context of something the respondent was interested in later in their career. Finally, a small number of respondents wrote something about life outside of a career, and here, starting a family was the most common theme.

Research Question 2: What are the motivations that drive students to choose a particular path?

Fourteen percent of the total responses were coded as "motivations"; these were generally explaining *why* the student wants or plans to do what they wrote. These were then recoded into more specific sub-codes, presented in Table 8. The most common theme among these respondents was helping others and using their skills to make a difference in the world. The second most common theme was having a life goal or dream they intended to work towards, with a trend of mentioning sustainability or alleviating environmental problems. These responses tended to be longer, with students giving more detail about why they were interested in a certain career path.

Table 8: Data for "Motivations" (n = 256)

Sub-code	%	Example Responses
Other	23	"We get recruiters from the finance industry all the time. It's hard not to walk out of the room on them. I want nothing to do with those vultures." "sit in a soft cushioned chair in an air conditioned office, perform easy engineering work at a desk. it will be a dream come true after working as an automotive technician for nearly a decade."
Giving back/ helping people	34	"I plan to use my engineering knowledge to better aid humanity. I am interested in a variety of subjects, but I want to change the world, not make tons of money. Sure, money is great, but as an engineer I feel it is my responsibility to aid humanity first. that is what I will do." "A massive part of applied CS (aka programming) is to be able to answer your own questions with wit and resourcefulness. With the money I'll make, I plan to open my own parkour gym and run it as a 501(c), so the gym is simply a part of the community I live in and not some profiteering business."
End goal for their life	25	"My dream is to develop defense software. This may involve working for a big tech company, starting my own company, or working for the army/DoD." "My goal is to work in power generation, transmission & distribution, or residential commercial application focusing on renewable energy. I believe it is paramount humanity reduces it's CO_2 production." "I would like to either pursue a PhD in neuroscience or neuroengineering to further my research in neurological control of movement to better understand and treat movement disorders (preferably at EPFL in Lausanne, Switzerland or MIT in Boston, Massachusetts), OR attend medical school in California and become a pediatric neurosurgeon to tackle the same problems from a different angle."
Work for specific company	3	"I am planning on working for The Walt Disney Company. I have 3+ years of experience with them as a Cast Member in their theme parks (in custodial, attractions, etc.). I plan to pursue a career with Disney long-term. I am interested in ultimately becoming an engineer responsible for daily operations of the theme parks or an Imagineer, which is part of the team responsible for developing new attractions and venues for the theme parks. However, due to the fact that these jobs are in high demand (and therefore very competitive), I am fully aware that I might not be able to get such a job immediately upon graduation. My "back up" plan is to work as a regular Cast Member in the theme parks (in other words, a job that pays an hourly wage, not requiring engineering experience), and working my way up to a salaried position, regardless of whether or not it is in engineering. Disney is a company that tends to promote their employees from within, and from the "lower ranks" of the company. I have no plans to return to school to pursue any further education, nor do I have plans to pursue an engineering-related job unless it is within The Walt Disney Company."

Desire to combine engineering with another field	7	"I will work in the Singaporean civil service trying to apply design thinking to policy making" "My ideal would be working with companies to perform research in South America surrounding technical communication translating between English and Spanish. I hope to be able to facilitate dialogue and innovation among the different countries in the Americas."
Inherent love of engineering work	10	"I feel that choosing my major was more about loving what I was going to be doing rather than making a bunch of money doing it." "I just would love to use my engineering knowledge to push the edge of innovation. Its fun to have a steady job and everything but I enjoy engineering the most when I am working on things hands on, experimenting, finding solutions/problems. I'll see where God will take me."
Secure future	13	"I am 37 years old and already employed doing R&D and controls engineering for a burner company. I am working on my degree to get the appropriate pay for the job I do." "This degree is a means to achieve financial stability. If I find a workplace I'm happy to work for, I'll consider myself lucky."

Overall, there are a wide variety of reasons respondents explained, providing a window into their thought processes and beliefs. With a strong theme of helping people and the world, as well as working towards a dream, there is a belief that engineers should help make the world a better place. However, there are also those pursuing engineering as a means to a secure future, or just because they love engineering.

Research Question #3: Are there significant differences between how men and women think about their futures?

Overall, women engineering students were overrepresented in the EMS sample, as 30 percent of respondents were women, compared with the national average of 19.9 percent women who graduate with engineering bachelor's degrees[10]. However, 30 percent of our open-ended responses were from women, which matches the overall EMS respondent pool. There were some main areas where women are over- and under-represented in their responses based on comparing the open-ended response pool (30% women) to the percentage of women whose responses were coded in a certain area. It is important to note that there is a small absolute number of people who discussed some of these factors, which limits the scope with which we can generalize these findings.

There were a few themes where women were overrepresented. In the "Engineering involved in plans" theme, more women mentioned they intended to leave engineering eventually (46 percent of responses with this code). This aligns with data from the NSRCG, which indicated that men were more likely than women to be employed in engineering jobs two years after graduation[2]. Women made up 48 percent of respondents who mentioned a trait of the work they were looking for in a job. In the "Life outside career" theme, 68 percent of the respondents mentioning

wanting to start a family were women. Lastly, 49 percent of students who mentioned "Teaching" were women. In 2012, 76 percent of public school teachers were women[11], so it is perhaps less surprising for women to be overrepresented in this theme.

There were also themes where women were underrepresented. Men more than women were interested in starting a business, with only 16 percent of respondents coded with that theme being women. This is in line with findings from the 2012 Global Entrepreneurship Monitor[12], which found that one in five men intended to start a business in the next three years, compared to only one in 13 women. In the "Life outside career" theme, men more than women indicated a desire to travel. In the "Motivations" theme, men were more likely to write about having an inherent love of engineering work (16 percent women) and about engineering as a means to a secure future (18 percent women).

Together, these data suggest that there may be some number of different factors at work for men and women engineering students as they think ahead to their future, although there are also large number of codes and themes on which there were no observable differences. Still, the finding that women were more likely than were men to discuss leaving engineering is striking in light of both consistency with trends in the engineering workforce and the fact that students appear to be "making the call" even before they have stepped foot in their first job. Which learning experiences in college help to explain plans that involve leaving engineering?

Next Steps for Analysis and Writing

Nearly all responses were coded with multiple themes. One next step in this analysis is to look for connections between themes, looking for patterns of students who mentioned similar sets of themes. One plan is to create example student profiles that highlight recurring links between themes, especially linking plans and motivations. Another goal for this research is to situate the "motivations" codes in the motivations literature, to better build on existing research.

Conclusion and Implications

Engineering students think about their future career plans in many different ways, though three main categories were identified: by wanting to work for a specific company, by wanting to go into a certain industry, or wanting to find a job with a certain trait. There are motivations that play into all of them, but in different ways, showing how different people prioritize differently when thinking about their careers. Understanding more about the motivations at work helps researchers and practitioners to think more comprehensively about the persistence of different students in engineering post-graduation, as many people who plan to leave engineering are doing it for reasons such as medical school, starting a family, working for a non-profit, or becoming a teacher - it is not because they do not enjoy engineering. In fact, many of these people hope to

use their engineering knowledge in another field. By disaggregating results by gender, we are able to gain insights into similarities and differences in men's and women's conceptions of their future plans are. Noting that this is only from the comments in response to this open-ended question and the small numbers of respondents mentioning a theme, a few differences emerge. Compared to the men who mentioned similar things, more women mentioned they intended to leave engineering eventually, wanting to start a family, a trait of the work they wanted to do, and to want to be a teacher at some point. In contrast, many more men were interested in starting a business, as well as were more likely to talk about their inherent love of engineering work.

All of this builds on previous research, adding insights into not simply what students want to do, but why and how they think about what they want to do. Especially as related to whether or not their future plans involve engineering, these data can help add explanations to the statistics about where engineering students go after graduation. The national averages show that about 30 percent of recent engineering graduates do not remain in engineering[4] - however, this would not account for students who intend to apply their engineering knowledge to another field. Additionally, it can help understandings of models of career goals, such as SCCT. SCCT shows that interests are translated into goals, and the three main pathways identified here for how students conceptualize interests into career goals can help add depth to understanding how this is manifested. This analysis also provides more depth to understanding what motivates students, showing how interests and learning experiences take a variety of forms that influence career goals.

We can use these insights to consider future research that might more fully capture the range of students' actual perceptions, worries, hopes, and plans about their futures. Taking into account the main three different ways students tend to think about their future plans, future survey questions could better capture students' thoughts about factors that will influence their job choices, as well as their perceptions about different career paths. Using the insights gained from students' motivations, future work could be centered around what students hope to accomplish with their engineering knowledge after graduation. Similarly, the insights gained from students who plan to leave the field of engineering can lead to future work around how these students may continue to use their engineering skills in other fields. Lastly, there is the potential for future work to be done to figure out why so many fewer women are interested in starting a business compared to men. Especially since entrepreneurship and innovation were major themes of EMS, there is much to be learned about why this difference appears in these data.

These insights can also help inform engineering practice. Understanding these main thought pathways can help engineering students figure out more concretely what is important to them when looking for a job, which helps both students as they navigate finding their first steps on their career paths, and anyone teaching or advising them about their career options. It can also help engineering teachers at all levels as they strive to make content relevant and meaningful.

Since the main motivations people have for being an engineer are around helping others or solving complex problems like our environmental impact, instructors can emphasize how their content can be used to accomplish these goals. Finally, this information can help inform efforts to support women in engineering, as they may think about their careers in a few different ways than do men.

References

1. Lent, R.W., S.D. Brown, and G. Hackett. *Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance*. Journal of Vocational Behavior, 1994. 45(1): p. 79-122.
2. Sheppard, S.D., A.L. Antonio, S.R. Brunhaver, and S.K. Gilmartin. *Studying the career pathways of engineers: An illustration with two datasets*. In A. Johri and B.M. Olds (Eds.), Cambridge Handbook of Engineering Education Research (pp. 283-309). 2014, New York, NY: Cambridge University Press.
3. Orr, M., Z. Hazari, P. Sadler, G. Sonnert. Career Motivations of Engineering and Non-Engineering Students: A Gender Study. In American Society for Engineering Education Annual Conference and Exposition. 2009. Austin, TX.
4. Brunhaver, S. *Early Career Outcomes of Engineering Alumni: Exploring Their Connection to the Undergraduate Experience.* Doctoral dissertation. 2015, Stanford, CA: Stanford University.
5. Winters, K. *Career Goals and Actions of Early Career Engineering Graduates*. Doctoral dissertation. 2012, Blacksburg, VA: Virginia Polytechnic Institute and State University.
6. Winters, K.E., H.M. Matusovich, S. Brunhaver, H.L. Chen, K, Yasuhara, S. Sheppard. *From Freshmen Engineering Students to Practicing Professionals: Changes in Beliefs about Important Skills over Time*. in American Society for Engineering Education Annual Conference and Exposition. 2013. Atlanta, GA.
7. Matusovich, H.M., R.A. Streveler, R.L. Miller. *Why do Students Choose Engineering? A Qualitative, Longitudinal Investigation of Students' Motivational Values*. Journal of Engineering Education, 2010. 99(4): p. 289-303.
8. Annotated Survey from Engineering Majors Survey Design Package. 2015. http://epicenter.stanford.edu/page/engineering-majors-survey
9. Creswell, John W. *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*, Second Edition. 2005, Merrill Publishing Company.
10. Yoder, B.L. *Engineering by the Numbers*. 2014: American Society for Engineering Education.

11. U.S. Department of Education, National Center for Education Statistics. *Teacher Attrition and Mobility: Results from the 2008–09 Teacher Follow-up Survey*. 2010. (NCES 2010-353).
12. Kelley, D.J., A. Ali, C. Brush, A.C. Corbett, M. Majbouri, E.G. Rogoff. *Global Entrepreneurship Monitor, 2012 United States Report*. 2012, Babson Park, MA: Babson College and Baruch College.