Work in Progress: Factors First-Year Students Consider During Engineering Discipline Major Selection

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Abstract

Demand for engineers in the United States continues to grow. While studies in retention frequently seek to address this problem, there are recent studies that report focusing only on retention may not maintain the needed supply because retention in engineering is not significantly worse than other fields. Therefore, this study will seek to identify the factors first-year students consider during their engineering discipline major selection process. Literature in major selection normally treats engineering as one field, without considering the individual disciplines; some of the literature also considers major selection by studying career choice, despite the lack of a perfect correlation between the two. To investigate the factors first-year students consider during their engineering disciplines major selection process, this Work in Progress paper will illustrate our approach to identify the factors using Social Cognitive Career Theory. A survey has been compiled from two existing instruments with some additional items written for this study.

Introduction

According to data from the United States Bureau of Labor Statistics, engineering jobs are expected to grow at an overall rate of 4% from 2014 to 2024, with some disciplines growing much faster than average [1]. Despite a growing demand for engineering graduates, a recent study has shown that only 28.1% of junior and senior engineering majors are probably or definitely pursuing an engineering focused career or graduate degree upon graduation [2]. However, a separate study of recent college graduates with engineering degrees shows that 60.1% were working in engineering fields [3]. These data show that more students work in engineering than are certain of it before graduation, but a substantial population of recent engineering graduates are not employed in engineering. Therefore, while predicting career choice can be valuable, simply selecting an engineering major does not guarantee an engineering career; this conclusion has also been supported by a study which investigated the extent engineering majors pursue engineering careers [4].

There does not appear to be a definite connection between student's major selection and their career choice. We hypothesize that motivation for major selection may help bridge that gap. One study has examined motivational differences between engineering majors [5]. These results have shown that there are significant differences among the engineering majors; for example, men in mechanical engineering are more likely to be intrinsically motivated than men in industrial engineering. However, men and women are generally motivated by similar means within a major, though some differences are significant in industrial and mechanical engineering. Therefore, we need to understand why students are selecting their engineering majors to ensure the demands of 2024 can be met.

Major Selection and Career Choice

Traditionally, students who desire to earn a bachelor's degree in an engineering discipline at a college or university will declare a major upon matriculation or at the end of a first-year engineering program. Whether or not the student is aware of it, their decision is generally guided and informed by many beliefs [6] and values [7].

Among the values often considered is the future value of being an engineer and/or having an engineering degree. Students studying engineering at a public research university located in the western mountain region of the United States, that specializes in undergraduate engineering education, had very different reasons as to why their career and/or degree will be valuable – for some, a financially rewarding career or benefits to society was a reason, but others viewed their engineering degrees as a "back-up" in case other plans failed [7].

Because of the disconnect between students studying engineering and choosing career paths outside of engineering, major selection is not necessarily a perfect predictor of career choice and the terms should not be used synonymously. Major selection is the decision of what to study at a college or university; for example, chemical engineering. Career choice is the field in which a recent graduate decides to work upon graduation; for example, paper processing and production. In this example, the student's major selection and career choice are in a common field: engineering. However, if the student had decided to pursue medical school or work in the financial sector, major selection and career choice would be in different fields.

Some students have dissimilar career choices with respect to their major. Because students decide about their major prior to making decisions about their career, it is important to understand why students select their major. Investigating the factors that lead engineering students to select their major will allow advisors to help students make better informed decisions as well as suggest or provide opportunities for students to explore their interests within or outside of engineering. While there are differences between major selection and career choice, we need to better understand the connections between them.

Work in Major Selection

While engineering can be regarded as a single field, there are many differences among the many individual majors offered within engineering that should not be overlooked. Some work has been completed that illustrates these differences. For example, one study has found that students perceive different engineering majors differently [8]; while students did identify many commonalities between majors, certain themes were more prominent in some majors than others. The idea of options was most related to mechanical engineering which the authors hypothesized as a possibility due to the discipline being viewed as a broader field.

Other work has examined students' movements and changes of major within their first year [9] and over their academic careers [10]. These studies investigated students who switched their majors in addition to developing trends on the paths students take. Students have cited changing interests as result of coursework as well as their (in)ability to meet academic requirements, such as GPA, for admission to their first-choice discipline, as the reasons for changing majors.

Confidence in major selection and the impact it has on graduation rates has also been investigated [11]. This work found that students who obtained their degree in the same engineering discipline that they matriculated into were the most confident in both that engineering was the correct career for them and that they were in the correct major. In addition, this study found that students who did not change their major had the most family members as engineers.

First-year engineering programs can also influence a student's major selection. Students who complete a program that allows them to explore the different disciplines available to them have reported the experience confirms their decision to pursue a particular discipline or provides them with the information to make their discipline selection [12]. This study also reported that even though students found first-year engineering programs helpful, most students were unaware of the matriculation model their institution used at the time of application.

Details About Our Project

Theoretical Framework

We plan to use Social Cognitive Career Theory (SCCT) as the framework for our project. SCCT strives to explain the interdependent relationship of people and their environment as it pertains to their career development by relating interests, choices, and performances. The theory seeks to understand how individuals exercise agency in their development as well as the instigating and mitigating factors that contribute to it [13].

SCCT has been used in engineering education research to study undergraduate students' decisions when considering graduate school [14] and student outcomes of group design projects [15]. The theory was developed by Lent, Brown, and Hackett [13] largely from Bandura's general social cognitive theory [16]. One core concept of SCCT is that individuals are not only products of their environment, but also create that environment which can lead to change [13].

SCCT uses three core constructs to consider personal agency. Self-efficacy is a person's own confidence in their ability to complete a task. Self-efficacy can be informed by classroom exercises, internships, social interactions with peers, abilities, and completing goals, among other things. Outcome expectations are the expected consequences, positive or negative, of completing a given task. Similar to self-efficacy, outcome expectations can be informed by the learning process, observing outcomes from the actions of others, as well as outcomes from previously performing a task, among other things. Personal goals are the desires and willpower to cause an outcome to become reality. Personal goals, as the name infers, are informed by the individual and are shaped by their self-efficacy and outcome expectations. This forms a cycle because as personal goals are achieved, self-efficacy and outcome expectations are informed which in turn shape our personal goals [13].

SCCT places interest, choice, and performance into three separate, but complementary models. The interest model incorporates interests primarily as a product of self-efficacy and outcome expectations and an informant of goals, though all these paths can be bi-directional because of the person-environment interaction concept discussed previously and because these models provide cyclic feedback. The choice model says, in the absence of a mitigating factor, people will choose options in which they have interests. Therefore, choice is informed by interests, but

can also be directly informed by self-efficacy and outcome expectations, the constructs that inform interests. The performance model identifies a person's accomplishments and their satisfaction with their accomplishments. While a person's performance can be directly informed by their abilities, it is also informed though their self-efficacy and outcome expectations because those constructs influence their personal goals with which their performance is compared [13].

Even though SCCT was developed as a model of the career development process, the authors believe that the theory would relate to academic interests, choices, and performances [13]. Therefore, we will use this theory to identify the most important factors first-year engineering students consider when making decisions regarding what engineering discipline to pursue as a college major. Further, we hope to identify the leading sources of self-efficacy that contribute to student's decision-making process.

Compiled Survey Instrument

A survey instrument has been complied that uses items from two existing instruments [17], [18] and includes some demographic items. The first set of items ask students about self-efficacy, outcome expectations, and goals, consistent with Social Cognitive Career Theory, our proposed framework. These items were originally developed for use with first-year medical school students who were in the process of selecting their specialty [17]. Items from the original instrument and edits that have been made for use in this study are illustrated in Table 1. We hypothesize that first-year medical students selecting their specialty use similar process as first-year engineering students selecting a discipline. This will be verified using a factor analysis.

Table 1. Survey items from the original instrument with the edited version for this study.

Item from the Original Instrument [17]	**Item as Edited to Appear in this Study**
How confident are you at this stage of your training that you could 1. Choose a specialty that will fulfill your expectations and goals	How confident are you at this stage of your training that you could: Choose an engineering discipline that will fulfill your expectations and goals
When thinking about the type of specialty that you are interested in (e.g., surgery, pathology, general practice) how much do you expect at this stage of your training, that your choice of specialty will 1. Be intellectually stimulating	When thinking about the type of engineering discipline that you are interested in how much do you expect, at this stage of your training, that your choice of engineering discipline will Be instinctually stimulating

The second set of items asks students exclusively about self-efficacy [18]. The items reportedly load onto four self-efficacy factors: general engineering, experimental skills, tinkering skills, and design skills. These items were designed and tested for use with undergraduate engineering students. These items will also be verified using a factor analysis.

Other data we plan to collect includes time since high school graduation, familial relationships with engineers, engineering experiences, and involvement in university activities. We will also collect standard demographic data. Sample items are included in Table 2. Analysis of survey data will likely involve multinomial logistic regression as well as traditional analysis of means, deviations, skewness, and kurtosis.

The complete survey instrument is included in the appendix.

Table 2. Items planned for this study from other instruments and developed for this study.

Item	**Ref.**
When you think about the type of engineering discipline that you might choose please indicate if, at this stage of your training, you agree or disagree with the following statements: I can master the content in even the most challenging engineering course.	[18]
When you think about the type of engineering discipline that you might choose please indicate if, at this stage of your training, you agree or disagree with the following statements: I can recognize changes needed for a design solution to work.	[18]
Do any family members you are close with hold any degree in engineering? If so, how many?	This Study
Please indicate if you have ever participated in the following. An engineering themed living and learning community / Engineering internship or co-op / Engineering job (full-time) / Engineering job (part-time) / FIRST Robotics / Engineering Club in high school	This Study

Potential Participants

The identified target population includes first-year engineering students at a large, public, research university in the southeastern United States. At the institution, students select an engineering major during their application process, but all first-year engineering students take the same core engineering coursework, though some students do take an Honors version of the sequence. During both first-year sequences of courses, students explore the disciplines available at the university and are free to change their major during the first year without the consequence of a delayed graduation timeline.

Path Forward

The survey will be distributed approximately two weeks after the college's primary major exploration event during the fall and spring semesters, approximately the middle third of the semester. The required event introduces students to the college's 11 engineering majors and

students submit a reflective assignment as part of their first-year engineering coursework. We hope to have some preliminary data to present at the conference.

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Appendix – Compiled Survey Instrument

How confident are you at this stage of your training that you could:

	1 (*no confidence*)	2	3	4	5 (*complete confidence*)
Choose an engineering discipline that will fulfill your expectations and goals	○	○	○	○	○
Choose an engineering discipline that will fit well with your personality (e.g., being an extrovert/introvert)	○	○	○	○	○
Choose an engineering discipline that will enable you to live the type of lifestyle you desire	○	○	○	○	○
Choose an engineering discipline that will fit your interests and abilities	○	○	○	○	○
Decide what you are and are not ready to sacrifice in order to choose an engineering discipline	○	○	○	○	○
Decide what you value most in an engineering career	○	○	○	○	○
Locate valid and accurate information to help you choose between equally desirable engineering disciplines	○	○	○	○	○

When thinking about the type of engineering discipline that you are interested in how much do you expect, at this stage of your training, that your choice of engineering discipline will

	1 (*strongly disagree*)	2	3	4	5 (*strongly agree*)
Be intellectually stimulating	○	○	○	○	○
Provide you with work satisfaction	○	○	○	○	○
Allow you interaction with you colleagues	○	○	○	○	○
Let you practice skills that best suit your perceived abilities	○	○	○	○	○
Provide you with a good income	○	○	○	○	○
Allow you to perform a broad spectrum of work	○	○	○	○	○
Be compatible with your interests	○	○	○	○	○
Allow you to achieve your desired professional success	○	○	○	○	○

When thinking about the type of engineering discipline that you are interested in how much do you expect, at this stage of your training, that your choice of engineering discipline will

	1 (*strongly disagree*)	2	3	4	5 (*strongly agree*)
Allow you to work the number of hours that you desire	○	○	○	○	○
Allow you to pursue leisure time activities/interests that you like	○	○	○	○	○
Allow you to have your desired work/recreational balance	○	○	○	○	○
Allow you to have your desired lifestyle	○	○	○	○	○

When you think about the type of engineering discipline that you might choose please indicate if, at this stage of your training, you agree or disagree with the following statements:

	1 (*strongly disagree*)	2	3	4	5 (*strongly agree*)
I have a clear set of goals for my future with regard to choosing an engineering discipline	○	○	○	○	○
I have discussed my goals in relation to my engineering discipline with my family/partner	○	○	○	○	○
I am taking the steps needed to achieve my goal of choosing an engineering discipline	○	○	○	○	○
I have examined my interests, values, and abilities in detail to come up with my goal of choosing an engineering discipline	○	○	○	○	○
I have a set time frame in which to make a decision about my choice of engineering discipline	○	○	○	○	○
I am getting lots of support to achieve my goal of choosing an engineering discipline	○	○	○	○	○

Please rate your level of certainty that you can perform these activities in engineering using a 6-point scale ranging from 1 (completely uncertain) to 6 (completely uncertain).

	1 (completely uncertain)	2	3	4	5	6 (completely certain)
I can master the content in the engineering-related courses I am taking this semester.	○	○	○	○	○	○
I can master the content in even the most challenging engineering course.	○	○	○	○	○	○
I can do a good job on almost all of my engineering coursework.	○	○	○	○	○	○
I can learn the content taught in my engineering-related courses.	○	○	○	○	○	○
I can earn a good grade in my engineering-related courses.	○	○	○	○	○	○
I can perform experiments independently.	○	○	○	○	○	○
I can analyze data resulting from experiments.	○	○	○	○	○	○
I can orally communicate results of experiments.	○	○	○	○	○	○
I can communicate results of experiments in written form.	○	○	○	○	○	○

Please rate your level of certainty that you can perform these activities in engineering using a 6-point scale ranging from 1 (completely uncertain) to 6 (completely uncertain).

	1 (completely uncertain)	2	3	4	5	6 (completely certain)
I can work with machines.	○	○	○	○	○	○
I can build machines.	○	○	○	○	○	○
I can assemble things.	○	○	○	○	○	○
I can disassemble things.	○	○	○	○	○	○
I can identify a design need.	○	○	○	○	○	○
I can develop design solutions.	○	○	○	○	○	○
I can evaluate a design.	○	○	○	○	○	○
I can recognize changes needed for a design solution to work.	○	○	○	○	○	○

What was your official major when you were admitted to ?

-- Select --

What is your official major today?

-- Select --

What do you expect your major will be at the end of the current semester?

-- Select --

How many official, unique majors have you had? (Please enter whole numbers only.)

Which of the following events, assignments, or discussions prompted consideration of changing (or selecting, if previously undecided) your major and/or made you decide to change your major? Select all that apply.

- [ ] Discussion with academic advisor
- [ ] Discussion with a professor in the College of Engineering
- [ ] Discussion with a professor outside the College of Engineering
- [ ] Discussion with friends or family
- [ ] Discussion with professional contacts
- [ ] Department Fair or associated assignment
- [ ] project
- [ ] assignment other than those listed
- [ ] Assignment for a class other than
- [ ] None of the above
- [ ] Other

What year did you graduate high school? (Please use the format YYYY; ex: 2018)

Is this semester your first semester enrolled in an Engineering course?

- Yes
- No

How many semesters have you completed at after high school graduation? (Please enter whole numbers only.)

How many semesters have you completed at institutions other than after high school graduation? (Do not include dual-enrollment or similar experiences. Please enter whole numbers only.)

In what year were you born? (Please use the format YYYY; ex: 1998)

What is your gender?

- ○ Female
- ○ Male
- ○ Non-binary / third gender
- ○ Prefer not to say
- ○ Prefer to self-describe:

What is your race?

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White
- ☐ Prefer not to say
- ☐ Prefer to self-describe:

What was your high school GPA? (Please round to one decimal place; ex: 3.7)

Using the table below, please indicate if you received college credit at for completing any of the following courses though AP, IB, dual enrollment, or similar experiences?

	Yes	No
Biology	○	○
Calculus	○	○
Chemistry	○	○
Computer Science	○	○
English	○	○
Environmental Science	○	○
History	○	○
Physics	○	○
Statistics	○	○

Do any family members you are close with hold any degree in engineering? If so, how many?

- ○ No.
- ○ Yes, only 1.
- ○ Yes, 2 or 3.
- ○ Yes, 4 or more.

Please list the engineering disciplines of the family members who have engineering degrees.

Please indicate the number of times you participated in an event or attended a meeting hosted by each of the following during the previous semester.

	0	1-2	3-4	5-6	7-8	9+
A professional engineering society	○	○	○	○	○	○
An engineering fraternity or sorority	○	○	○	○	○	○
A professional student group for women or minority engineering students	○	○	○	○	○	○
The Multicultural Engineering Program	○	○	○	○	○	○
An academic department in the College of Engineering	○	○	○	○	○	○
The Center for Career Development	○	○	○	○	○	○
The Student Success Center	○	○	○	○	○	○
University Libraries	○	○	○	○	○	○

Please indicate if you have you ever participated in the following.

	Yes	No
An engineering themed living and learning community	○	○
Engineering internship or co-op	○	○
Engineering job (full-time)	○	○
Engineering job (part-time)	○	○
FIRST Robotics	○	○
Engineering Club in high school	○	○

Please list any other experience you have had that has contributed to your understanding of engineering at large or to any engineering sub-discipline.
