Examination of Student Choice to Remain in Engineering

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Abstract

This research paper investigates motivations and decision-making of undergraduate engineering students. Building on prior research exploring major selection across many disciplines and demographic groups, this work examines response data from students in engineering majors across four years of undergraduate study. All these students began their undergraduate programs as "pre-majors" in engineering. At this large Midwestern public university, engineers are not fully admitted to their majors until prerequisite coursework is complete. The coursework required for admittance can vary from discipline to discipline. This variation as well as variation among application deadlines and GPA cutoffs across discipline can play a role in whether a student pursues the major they entered university intending to pursue. At the time of the final survey, these students were in their fourth year of study. These students throughout the four years chose a variety of paths; some stayed in the same concentration of engineering from pre-major to graduation, and some left engineering altogether. This collection of data allows a unique comparison between individuals who remain in engineering throughout college, and individuals who begin their studies intending to pursue engineering, but at some point choose to leave engineering altogether. The paper primarily focuses on survey response data from this group of students collected during their fourth year. Our analysis examines comparisons between responses among students in their first year with whether those students eventually leave engineering. We use this information to compare students who stayed in engineering against those who left using quantitative data on how certain and interested they initially were in engineering as well as qualitative responses describing why they switched disciplines or left engineering.

Introduction

As STEM students and workers gain national attention, a growing body of research seeks to examine why students choose to pursue STEM-based majors as demonstrated in many previous reports [1]-[4]. Supporting this growth, the National Science Board put together a report examining the STEM pipeline, the process of students moving from early education, through high school and college, and into STEM careers [5]. Because choosing a college major influences so many parts of a student's life (anything from daily interactions with peers to long-term career goals), it can be an overwhelming decision. The pressure to make a decision may push students to choose a path unsuited for them, prompting them to switch majors or leave college altogether. Specific to this work, little previous research examines what happens in engineering as students move in and out of their majors. As colleges seek to improve retention, understanding that first step into a major is crucial. Helping a student make the right choice early on may help reduce attrition rates.

The choice of discipline is not a simple one. It may involve pressure from family or culture to pursue a specific field. Additionally, complex questions must be answered. For example, where will I succeed? What will life in college be like? What will life after college be like? These influences can conflict with one another, pushing a student in multiple directions. Because of these external influences, as well as a student's own internal motivations, choosing which major

is most suited for them is not a simple or easy task. Understanding major choice will help colleges better support their students.

Background

The choice to pursue engineering is made by many students every year across the world. Even though many students begin their college careers with the intent to attain a degree in engineering, some students eventually leave the college of engineering for other majors and some even leave for opportunities outside of school all together. As the field of engineering education research grows, more opportunities arise to examine what happens between the declaration of a major and the planned graduation date that prompts so many students to exit the field. Much research discusses how and why students initially choose a major (e.g., [1],[6]), but further discussion of what happens between major declaration and planned graduation date is lacking in the existing literature.

Major selection is the focus of a large body of research involving higher education (e.g. [1], [2], [7], [8]). Research looking into major selection has been pursued from a variety of perspectives. Some research has focused on a broad range of college majors using performance measures to analyze selection. The Arcidiacono [9] study found that preference for in-college experience outweighed monetary returns to different majors when students decided which degree to pursue. While this study yields valuable insight, it does not address why students leave a major.

Some research focuses on groups of majors, such as STEM or business majors (e.g. [6]). In contrast to the study by Arcidiacono, the results of the Montmarquette et al. study indicate that major selection depends highly on the multifaceted factor of anticipated monetary returns to college education. Major selection for this study was modeled as the choosing of a concentration, like ‘business’ or ‘science’ [6]. Grouping majors in this way is useful when examining choice of major through a broad lens but neglects the nuance between majors in these groups. It also further highlights the necessity of more detailed studies like this current study; these previous research studies examine major selection in a broad lens, while this current study presented in this paper narrows the focus to one field: engineering.

One study similar to the one presented in this paper examines some of the same survey data from first year engineering students, but still does not distinguish between engineering majors [10]. Still another examines attrition from engineering based on grades without noting whether or not the majors are different from one another [10]. The Meyers et al. [10] previous research allows us to build a more longitudinal approach for additional analysis. While some of the data is the same, our study branches further into examining why students stay in or leave engineering. There has been some previous research investigating relationships between demographic variables and engineering fields, but leaves out the student perspectives and expectations in choosing a major [11]. With this in mind, we focus on engineering specifically with our data from students in first year engineering coursework analyzing their expectations by reading the response data from surveys.

A large portion of previously conducted major selection research comes from the perspective of trying to introduce more people into STEM fields. For example, another study approaches the

participation of minorities in STEM from the perspective of examining why they leave. This study proposes stereotype threat as having an influence on the participation of individuals in STEM majors [12]. Another study examines the participation of women in engineering as it relates to interest and participation in a women in engineering program across all four years of college [3]. While this is a relevant topic for diversity and inclusion, it does not fully answer the question, why stay or leave? Yet another study of women in engineering compares the rate of women and men leaving engineering years after working in industry with a degree, with women leaving at a much higher rate than men [13]. Further research explores how school work before college can predict major declaration at the start of college [1], [14]. An exploration into course availability revealed that higher math and science courses offered to a student does not meaningfully predict engineering major declaration, but did reveal a disparity of course availability and enrollment in high school among various ethnic/racial groups [14]. As demonstrated by these many research studies, life before college plays a large role in major selection but does not take into account the influences present once college begins. Discovering how students are confirmed in or swayed from their initial choice is the motivation for this current study.

Previous research in this area has investigated major selection and academic life during many different time periods of a student's life. Much of the research regarding academic life and behavior focuses on the years before college: from birth until the end of high school (e.g. [1], [4], [15], [16]). The majority of this research addressing life before college examines the experiences of a student in high school [1], [4]. While several studies choose to examine the more broad time frame of "adolescence" [15], [16]. Some research addresses life in college rather than before: one such study examines the influence of a randomly assigned paper topic on the likelihood a student will pursue the major in the field of their assigned paper [17]. Another study examined how certainty fluctuates over the course of college, and which experiences play a role in this [3]. While these studies probe the process of major selection while in college, the focus of their scope is early college. The purpose of our study is to investigate what happens over time as students continue in their studies as engineers or choose to leave engineering. Without much literature investigating this area, our study examines survey data from students spanning four years of their college careers.

The topic of major selection has also been examined in a handful of other perspectives. One study tracks completion rates as colleges switch from all majors as separate choices into groupings of majors called "meta majors." The idea behind this is that a student could initially choose a general focus before selecting a particular major. This restructuring was done in the hopes of increasing college completion rates [18]. Of primary interest to our research, several studies examined why people leave the engineering industry (e.g. [13], [19]). Yet prominently lacking from this research is an investigation into why engineering majors switch out of engineering in college. As shown, research has looked at why a student would choose STEM in the first place, as well as examine why someone would leave industry. But no studies found directly addressed why an engineer would switch to a different major. Only one study compared data of students who left engineering to students who stayed [3], but that study does not contain qualitative information that would explain from a student's perspective why they would switch from engineering. Using purely quantitative data does not acknowledge the complexity that

comes with student decision making in major selection. Within our study we have examined student responses holistically by combining the qualitative and quantitative data.

There is much available research into major selection among college students. The previous research examines many perspectives but leaves a gap this paper works to fill: what happens between initial selection, and graduation? By examining survey data across multiple years at a large Midwestern public university, our research explores the movement among majors between initial selection for an engineering student, and their final year.

Methods

To analyze the difference in perspective between students who stayed in engineering and students who left, survey data was collected in two surveys spaced three years apart. The first in autumn of 2014, the second in autumn of 2017. Surveys had qualitative and quantitative questions but differed slightly in the details of the questions. In this study, one qualitative question from the initial survey will be examined ("Please describe your impression of what an engineer in your discipline could do in the workplace"), and three from the final survey (("Please describe your impression of what an engineer in your discipline could do in the workplace", "please explain what led you to change out of engineering", and "please explain what led you to change your engineering major").

The repeated question was coded using a codebook developed in previous research [20]. This codebook was developed for the same survey, but the previous work analyses the responses in a different light. The different question: leaving the college of engineering was coded using codes developed for this survey. These codes were developed by reading through response data, taking note of, and grouping trends.

Survey Questions and Analysis

To collect data, a series of surveys were sent out to students in first-year engineering courses beginning in the autumn of 2014. For this work, we are focused on the first survey from that set. Additionally, a final survey was sent to students in autumn of 2018. We chose these two specific surveys to represent a longitudinal perspective of student experiences across their undergraduate experience. Each survey question, what survey the question appeared in, and the question data type is given in Table 1.

The codes and definitions are from previous research analyzing some of the same survey data [20]. This previous study used the qualitative responses from the first survey to develop a codebook that highlights major trends in the data. The nine codes that were developed in the previous research and used to analyze this data are included in Table 2 along with an example of each code from the dataset used in this research. The number given in parenthesis corresponds to a specific student.

Table 1: Survey question details including which survey they appeared in.

Question	Survey		Question Type
How certain are you that engineering is the best academic major for you?	Pre	Final	Quantitative
How interested are you in engineering (as compared to other academic majors)?	Pre	Final	Quantitative
How certain do you feel about your engineering discipline selection?	Pre	Final	Quantitative
Please describe your impression of what an engineer in the discipline you selected above could do in the workplace. *How does this compare with what you plan to do after you graduate? (added on final survey)*	Pre	Final	Qualitative
Please explain what led you to change your engineering major:	Final		Qualitative
Please explain what led you to change out of engineering:	Final		Qualitative

Table 2: The codes used to analyze the data and examples of each from the current dataset.

Code	Example
Applying Knowledge	"A mechanical engineer uses knowledge of physics and math in order to design products/systems that can help to solve problems/make processes more convenient." (884)
Location	"Plastics, oil and gas, food, rubber, specialty chemicals, polymers, and any other process or manufacturing engineering. I plan to work in one of these fields." (3722)
Options	"A biomedical engineer in industry could design implants, model biological systems, run product development for consumer product companies, many other things. In contrast I plan on attending medical school." (4466)
Problem solving	"They would solve problems. I plan on solving problems for my employer." (7111).
Process	"An engineer in this discipline could work as a software developer, go into Artificial Intelligence, Computer Graphics, etc. I plan to go into software engineering after graduation." (1532)
Research and Design	"My plan is to go into the automotive research and development field. With a specific focus on controls" (1329)
Build, Maintain, and Improve	"We improve processes through data analytics and statistical studies. We also work on making the workers life easier by making the job easier, either physically or mentally. We make the costumers lives easier by increasing quality through decreased variation." (2499)
Serving Others	"Work in a plant setting doing work on chemicals, food, oil, etc. I hope to do something that helps change the world." (6496)
Working with Others	"There are many options for careers in mechanical engineering. Usually MEs receive a project and work with others to complete it. I imagine myself working in the automotive industry working on projects that improve a segment of the vehicle." (6031)

As demonstrated by the responses shown, a single response can address multiple codes. To account for this, we assigned each response up to two codes. Each of these codes counted for the same weight when counting the responses that addressed each code. Using multiple codes allowed us to more fully represent the nuance present in many of the responses.

Additionally, of the students who left engineering, an open-coding technique was used to examine the reasons they left engineering.

For the quantitative statistics, students were initially split into two groups: students who stayed in engineering through the final survey, and students who left engineering sometime between the initial and the final survey.

Results

Qualitative Data Analysis

For the qualitative portion of the analysis, codes were counted to analyze patterns among groups of respondents. The two compared groups in this analysis are qualitative responses from students on the initial survey who would complete their degree in engineering compared to responses on the initial survey from students who would eventually leave engineering. This is shown in Table 3 and Figure 1.

Table 3: Qualitative response coding counts and codebook definitions from pre-survey data comparing the students who stayed in engineering and the students who left.

Code	Stayed in engineering (n=141 codes = 119)	Left engineering (n=33 codes = 50)
Applying Knowledge: Including a requirement that certain information must be known to solve a problem. Contains the mention of specific concepts relevant to the field	7%	2%
Location: Including a specific place, company, or industry mentioned by name	8%	4%
Options: Using engineering as a means to a wide variety of ends, areas of specialization within the field, or acknowledgement of general versatility. This may be a statement about options or a list of different options	18%	20%
Problem solving: Using logic to solve current issues	5%	4%
Process: Viewing engineering as a sum of its actions. Includes mention of specific tools or material	8%	12%
Research and Design: Engaging in the development or conceptualization of a product or process	24%	22%
Build, Maintain, and Improve: Engaging in the creation, construction, upkeep, and enhancement of a product or process to progress efficiency	18%	12%
Serving Others: Wishing to protect or better the lives of individuals or society as a whole	8%	16%
Working with others: Working with or leading a team on collaborative endeavors	6%	8%

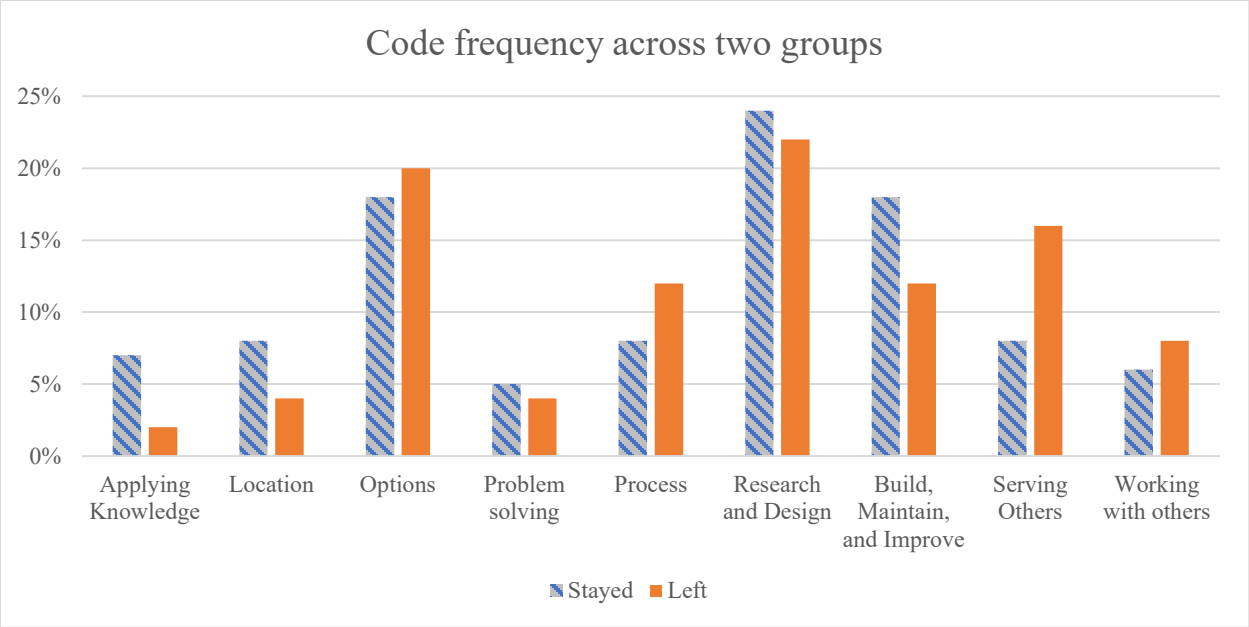

Figure 1: Bar graph of code frequency comparing the students who stayed in engineering and those that left.

Through the open-coding technique while examining the data in this study, two themes were noted among students describing why they left the college of engineering. The two major trends of those students were either leaving engineering because of something within their major they disliked, which we coded as "Push", or leaving engineering because of something else that they found more appealing, which was coded as "Pull". These are described below in Table 4. However, because the sample size of the students who left engineering is very small (N=33), the resulting sizes of the "Push" and "Pull" groups are too small to derive conclusions or to do any further analysis. They are included in these results to provide a foundation for future research questions.

Table 4: Shown is a further separation of the students who left engineering.

Code	Definition	Example
Push	Discussion of attrition from engineering based on some aspect of either the department they were studying in, or the engineering coursework/subject matter.	"Did not like the physics/engineering classes I was taking, was not interested in careers I could pursue with my engineering degree" (7290)
Pull	Discussion of attrition from engineering based on something external to engineering (i.e. a new interest or major that's more appealing).	"I found Accounting to be much more exciting and interesting to me." (1599)

Quantitative Data Analysis

In examining the results from the initial survey across students who left and students who stayed, we used a Mann-Whitney U-test in SPSS to determine whether there were statistically significant differences between the survey results from students who would eventually leave engineering and students who would stay in engineering. This data is from the same surveys and students represented in the qualitative data. The quantitative portion is from the Likert-scale data gathered from the survey questions.

Table 5: Statistical survey results showing which instances result in rejection of null hypothesis.

Null Hypothesis	Test	P-value	Decision
The distribution of discipline certainty in the initial survey is the same across categories of stay or leave.	Independent-Samples Mann-Whitney U Test	0.777	Not statistically significant: Fail to reject the null hypothesis
The distribution of engineering interest in the initial survey is the same across categories of stay or leave.	Independent-Samples Mann-Whitney U Test	0.026	Statistically significant: Reject the null hypothesis
The distribution of engineering certainty in the initial survey is the same across categories of stay or leave.	Independent-Samples Mann-Whitney U Test	0.032	Statistically significant: Reject the null hypothesis

Discussion

The two results of statistical significance were the distribution of engineering certainty and the distribution of engineering interest on the pre-survey when students who would eventually leave and students who would eventually stay were split into two groups. The data indicates that there are quantifiable differences between the students in this sample who would eventually leave engineering and students who would continue in the college in both interest in engineering as well as certainty. This shows that even before students reach their fourth year, there are differences between students who will eventually leave and students who will eventually stay. While this information does not allow us to predict a student's behavior based on survey data, incorporation of these themes in introductory coursework may aid students as they make their choices.

When analyzing response data after dividing the students who eventually left from the students who eventually stayed, it became apparent that some codes were preferred by one group or the other. For example, students who eventually left more frequently mention the codes "serving others" and "working with others" while students who eventually stayed more frequently mention "build, maintain, improve," "location," and "applying knowledge." This seems to indicate a pattern of long term engineering students' focus on the more technical parts of engineering, while students who would eventually leave discuss human interaction portions of engineering with more frequency.

Conclusion and Future Work

Between the two comparison groups, students who would stay and students who would leave, the students who left had more interest in interacting with and serving other people as shown in Figure 6. This can be addressed in engineering coursework by showing to students the humanity-focused goals of engineering and the many ways that engineers can improve their world. Engineering can also be used as service to other people to improve their lives. The two groups also show differences in quantitative data in certainty and interest in engineering. This shows that it may be fruitful to address what a student wants from college, as opposed to addressing their expectations in a major. Since there are not major differences between these groups when discussing what they thought an engineer in their discipline would do in the workplace, addressing this expectation may not be fruitful. But there is a difference in how interested these students are in engineering. It may be more efficient to push students to self-examine their motives for choosing an engineering major while they are still early on in their programs. If interest is a large driving factor for students, it becomes imperative that students understand their own internal motivations for pursuing a major. Without self-understanding, these students may find themselves in a degree program that holds little interest, and they may find themselves searching for another program or contemplating leaving college.

Major inhibiting effects on our study come from the small sample size. For future research in this vein, more information from students leaving engineering would be necessary. If a major focus of research is why students leave a major, then pursuing information from that group becomes a challenge necessary to address in the data collection phase. One possible way of countering this sampling issue would be to give academic advisors the desired survey to send to students as they notify their advisors of their attrition from engineering.

For future research into reducing attrition, deeper analysis into how students feel about their majors may be a better route than looking into their expectations. This could be done through further survey of students or by conducting interviews. While the "Push" and "Pull" data was too small to be analyzed further in this study, it does provide a topic for future survey or interview questions.

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