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Chemical Engineering Major Selection Throughout the First Year: A Mixed-Methods Approach

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Abstract

For any student in the first year of an undergraduate program, there are an overwhelming number of decisions to make. One of the biggest of these is choosing what to study. This choice is influenced by many complex factors and is difficult to predict or fully understand. A better recognition of why a student opts into and stays in a major could yield a deeper understanding into how students choose a major and what they expect from engineering careers. This paper examines students who chose chemical engineering and completed a set of surveys administered during their first year of study. The surveys contained questions that were both quantitative and qualitative in nature. In total, 32 complete response sets were included in the analysis from students who answered all three surveys and chose chemical engineering as their major in any of the three surveys. These responses were selected to investigate the major selection path of students who opt in and stay in the chemical engineering program by the end of their first year.

Introduction

There is a large body of research concerning how a student chooses a college major, but little of this literature narrows down majors beyond concentrations or categories like STEM or Natural Sciences [1]. There has been research into the initial decision of choosing a major with two primary focuses: experiences before college and anticipated salary after college [1, 3, 4]. For example, Montmarquette et al. [1] differentiated major selection through four major areas and used generalizations about these areas to model data and demonstrate a trend in choice relying on expected post college income/earnings.

A study by Arcidiacono [2] examined student ability and selection into various majors. In that study, researchers investigated the relationship between the sorting and preferences in major, with the conclusion that primary factors in sorting are due to preference in what the major is like in college as well as what the career itself is like. The study noted that the in-college preference had a stronger effect than the preference for after-college experience. While this study did narrow the majors into focuses: natural science, business, social sciences/humanities, and education, it did not go into any detail within each of these concentrations.

Bottia et al. [3] examined high school/pre-college experiences for students considering choosing STEM majors and concluded that strong factors in declaring a STEM major are taking physics in high school, and, while still in high school, planning to declare a STEM major once in college. The paper also discussed the positive effect of extracurricular STEM activities in school, and that increasing these experiences for students will better the odds that students will pursue STEM in college.

A study by Xia [4] investigated more financial motivations. They estimated that students use information about their family members' incomes as models for what they would earn in a similar career. This research concluded that students are more likely to choose the career path of a sibling or parent if that individual has a relatively high income. This study did not narrow down majors any further than business, engineering, and science as higher-earning paths. Studies such as this lay the foundation for other studies that differentiation between engineering majors such as the work we conducted.

These previous papers approach major selection from multiple angles, yet they still leave room for growth. There is little to no differentiation between actual majors, rather it is all between larger areas of focus. While much of the existing literature examines complicated details revolving around a student and their choice of college major, it does little to consider their understanding of this choice. The perception of the consequences of any action plays a key role in decision, yet the literature is largely lacking in this. Studies focus on external factors like data gathered concerning which courses were studied in high school or what a reasonable salary might be for that major [1-3]. However, they do not contain data from the students themselves on their perception of the career path. Many of these studies treat the choice as reliant solely on quantitative measures: scores from the Armed Services Vocational Aptitude Battery (ASVAB) test [1], STEM high school classes and experiences [3, 5], and standard earnings for careers [4]. Belief in one's own ability can affect choice of major [6], as can grades in college [7]. The relationship between identity and major selection has also been explored in several ways including gender [8] and socioeconomic background [1]. These do not portray the fuller picture of what a student believes they would do in their jobs since they primarily address prior experiences or personal identity rather than future expectations. Our work aims to fill this gap.

While previous literature does explore the realm of major selection, it lacks in-depth exploration of individual majors. This paper will help explore this area by focusing on chemical engineering as the major of choice. The driving question for this paper is: *Based on perceived careers, why do first-year engineering students choose chemical engineering as their major?* We investigated this research question by examining information about students' beliefs about what chemical engineers do in the workplace and they certainty that this major was the correct choice for them.

Methods

This project used a mixed methods approach through surveys that contained both quantitative and qualitative questions. The set of three surveys were administered. The data was gathered over the course of one academic year from first-year engineering students at a large land-grant university.

Participants

The survey participants were first-year students enrolled in engineering majors at a large land-grant university in the Midwest. The students in the engineering program at this school are admitted to the program as a "pre" major during their first year. The engineering program includes a year of introductory coursework before applying to their selected discipline within engineering. To help with major selection, students are exposed to a variety of engineering disciplines to educate them on what each discipline is, the types of courses they would take in the program, and the types of jobs and careers available.

The participants selected for this study were part of a larger effort related to this work. In the larger study, quantitative data responses were received from 927 students on the first survey, 743 students on the second, and 656 students on the third. For the scope of this paper, the responses were narrowed down only to students who declared chemical engineering as their intended major on any of the three surveys. It was also restricted to students who completed all three of the surveys so that we could follow them longitudinally through their engineering experience. This reduced the number of examined responses for this paper to 32 in order to view the data in more detail allowing the quantitative and qualitative components to be analyzed together. We recognize this is a small sample; however, it is a rich sample given the data we have collected on these students. This small sample allows for an in-depth examination that may not otherwise be possible with a larger data set.

Survey

The same survey was sent out at the beginning, middle, and end of the academic year in an electronic format. Students were asked to discuss their own major and describe what they thought an engineer in that discipline would do in the workplace. The survey consisted of both quantitative and qualitative questions. The quantitative questions were numerical ratings on certainty in the student's choice of engineering as a whole and their certainty in their discipline of engineering. These questions were answered on a 5-point Likert Scale. The qualitative questions asked students to explain their perceptions of what someone who works in their field would do in their jobs. The questions used in our analysis are given below.

Table 1: Survey Questions

#	Question	Question Type	Response Type
Q1	How interested are you in engineering (as compared to other academic majors)?	Quantitative	Answers were given as a 1-5 numerical certainty.
Q2	How certain are you that engineering is the best academic major for you?	Quantitative	Answers were given as a 1-5 numerical certainty.
Q3	At this point, which engineering discipline are you most interested in?	Qualitative	Answers were chosen from a list.
Q4	How certain do you feel about your engineering discipline selection?	Quantitative	Answers were given as a 1-5 numerical certainty.
Q5	Please describe your impression of what an engineering in the discipline you selected above could do in the workplace.	Qualitative	Answers were written out as qualitative responses.

Analysis and Limitations

The analysis for this paper included both a quantitative and a qualitative component. The quantitative data was explored using descriptive statistics. Due to the small sample, this type of analysis seems most appropriate. The qualitative analysis was an extension of a previous study with multiple institutions [9]. The previous study used respondents across three different universities and used responses only from the first survey. The coding used for that work was applied to the data set of this paper which included the second and third surveys. The original coding process was done by two coders analyzing a small sample set to identify themes, following the recommended method described by Patton [10]. Their approach was used to allow trends to emerge without distortion. The prior research with these responses and codes that this paper builds on processed the codes iteratively and relied on literature to support the analysis [11, 12].

While it was helpful to limit the scope of this paper to 32 respondents for the purposes of the detailed analysis, it presents some limitations. Primarily, the number of students represents a small percentage of the engineering students at the large land-grand university used for the pool of participants. Limiting the pool to only students who declared chemical engineering as a primary interest in any of the three surveys as well as those who completed three surveys removes those students who completed only one or two of the surveys. It is possible that these other surveys contain interesting data but including them would remove consistency in respondents from the data. These responses could provide additional insight into student perceptions of engineering, as could the responses from those who selected other majors and may be considered in future work.

Results

Figure 1 is a representation of students moving through different majors over the course of the surveys. The number of lines up from chemical to other represents the number of students switching out of chemical engineering. The number of lines down from other to chemical represents students switching into chemical engineering from other majors.

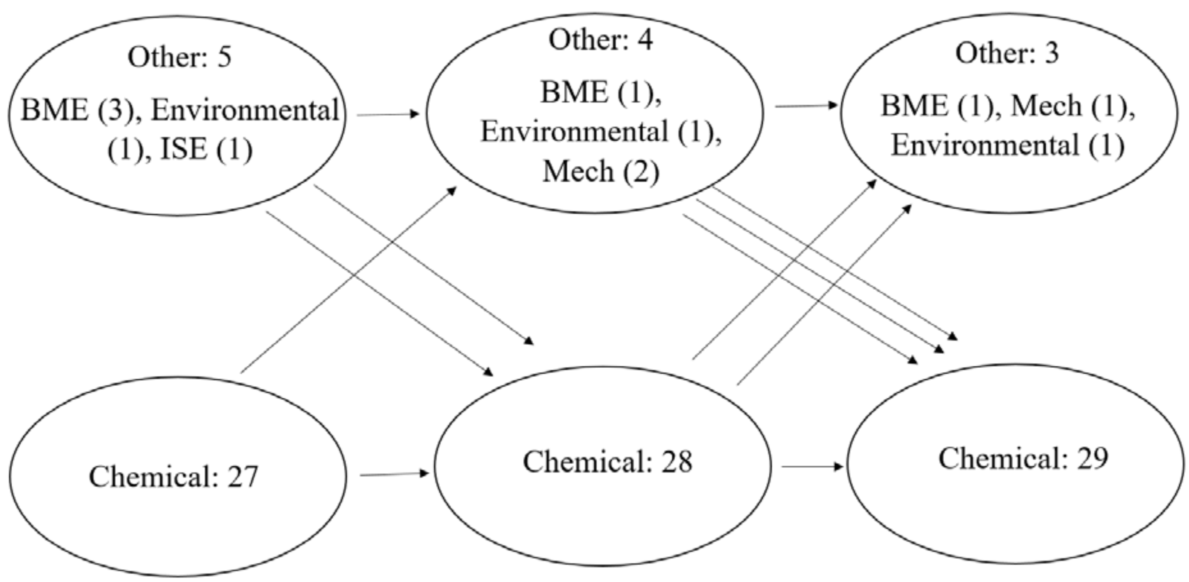

Figure 1: Changes of Responses to Question 3 across Surveys

The data in Table 2 represents the average response received for the quantitative questions from chemical engineering students. Each question was answered on a scale of one to five. As Table 2 shows, certainty in chemical engineering increases for this data set. Table 3 represents the average of the quantitative responses from students who chose a major other than chemical engineering for that survey. As shown in the table, certainty in an engineering discipline decreases for this data set, which is the opposite trend than that for chemical engineering majors.

Table 2: Quantitative Averages: Chemical Engineering Majors

		Pre	Mid	Post
Q1	Engineering Interest	4.70	4.79	4.79
Q2	Engineering Certainty	4.15	4.36	4.38
Q4	Discipline Certainty	4.15	4.04	4.34

Table 3: Quantitative Averages: Non-Chemical Engineering Majors

		Pre	Mid	Post
Q1	Engineering Interest	4.60	5.00	5.00
Q2	Engineering certainty	3.80	4.50	3.33
Q4	Discipline certainty	4.20	2.75	3.33

Table 4 represents the qualitative data collected for chemical engineering students as simple counts and how the responses from the survey questions were coded. Many responses were given both a primary and secondary code assigned to the response. These have been given the same value in the data. Table 4 shows that the codes *Process* and *Research and Design* increase over three surveys, indicating a greater focus on these concepts over the students' first year.

Table 4: Qualitative Data: Chemical Engineering

	Number of Codes by Survey			
Code Name	Pre	Mid	Post	Total
Problem solving	2	2	2	6
Research and Design	1	5	8	14
Build, Maintain, and Improve	9	10	9	28
Serving Others	4	3	0	7
Options	17	10	12	39
Working with others	0	0	0	0
Applying Knowledge	4	4	0	8
Process	6	10	13	29
Location	9	7	6	22

Discussion

This data is restricted to students who chose chemical engineering at any one point over the course of one academic year. The student responses were separated in each survey into two major categories: (1) students who had selected chemical engineering as their major for that survey and (2) students who had chosen another major for that survey.

The most notable shift in the qualitative responses is the decrease in students discussing options. This code is used when a student mentions the flexibility an engineer in their field has or the range of careers other than engineering available to someone with an engineering degree. This shift in students' discussion options could be related to students focusing on their career path as the year progresses. As an example, excerpts from one student's track through the year follows:

> **Pre Survey Response:** "My impression is that Chemical Engineers can do a very wide range of things in the workplace. [An instructor] even described the many things she had done after graduating. I'm also aware that many CEO's have chemical engineering degrees."
>
> **Mid Survey Response:** "A very wide range of things hopefully dealing with fluid mechanics though."
>
> **Post Survey Response:** "Fluid mechanics is a huge component."

This student has shown a clear transition over the course of the year from a vague idea of the breadth of engineering to a specific understanding of what an engineer can do. The student seems at first to focus on the wide range of ideas and possibilities. By mid-year, an interest is shown in one specific aspect of the professional world. At the end of the year, the student has completely stopped discussing the breadth of engineering and has narrowed down the discussion to one aspect of the technical world. The first two responses were coded as options, but the third one is not. This shows a clear progression from seeking a broad array of options to narrowing down to one component of chemical engineering.

It is also possible that this trend in the qualitative data is related to a trend in the quantitative data. Across the three surveys, the value for discipline certainty among students who chose chemical engineering for that survey increases. It is possible that as students narrow down their understanding of what a chemical engineer does in the workplace, they either become more certain in their choice of a major or they switch into a different major. This would explain the increase in certainty among chemical engineering students as well as the decrease in options discussion in the qualitative data.

Throughout the first year of the engineering program, the survey participants are exposed to more information and discussion surrounding various engineering careers and majors. This exposure could possibly draw them to specific career paths. Once their plans narrow, they may be less interested in the breadth of options available to them after graduation.

The frequency with which students mentioned *process* increased over the course of the year. *Process* includes places where students discuss more specific elements of an engineering job. This could include an individual task done on the job or a tool used. Like the student above who narrows down to one specific component of the field, another student reaches a more specific idea of what engineering could look like:

> **Pre:** "I see chemical engineers as the innovators of the future. They help to create new base substances that are then used to help other disciplines create even more different technology. I think that chemical engineering just seems to affect so many people."

> **Mid:** "I see them as creating useful substances like new compounds that make products more efficient and less wasteful. I think it is a place where you are able to improve products thus improving society."
>
> **Post:** "One major thing I think of when I think of chemical engineers is polymers. I think it would be interesting to design and work with different polymers in product design."

The student above demonstrates the trends in the responses that reflect a shift from a general idea of what engineers could do to a specific idea. The responses have a trend of growing more concrete over the course of the surveys. A possible reason for this increase could be similar to why the number of students mentioning options decreases. If students pay more attention to the details of their careers and begin to narrow down what they want to do, it is possible that they would then have a better understanding and increased ability to discuss the specifics of their job. As students narrow down their interest in their fields, they could become more certain that engineering is what they want to pursue in college. The students seem to become interested in specific components of the field rather than its breadth.

Conclusions and Future Work

Students that selected into chemical engineering and stayed in the major seemed to only grow more certain with time that they have chosen the best major for them. But students that switch from chemical engineering into another major have lower certainty in their major. This is an interesting point of reflection. In parallel with this qualitative data, there appears to be a parallel in student responses. Students that stayed in engineering over time became more certain of their major and narrowed down the field to specific components in their discussion of career possibilities. This information and insight can be useful for advisors and faculty when talking to students about their major selection.

Possible expansions of this work include extending the time frame of the survey. Sending the survey earlier on to students who are still in high school, and thus in the initial stages of major selection, could give insight into how students form their ideas of engineering. Since students still switch majors after the first year, extending the survey beyond the first year would also give a longer-term perspective in switching majors. Including students who chose chemical engineering at some point during the year but not for the full year would demonstrate a change in the thinking of the student. Examining that data in addition to the data included in this paper would give further insight into the changing elements of student perceptions of an engineering major.

Overall, it appears as though a student's detailed knowledge of a career path is loosely connected with certainty in a major. Providing more concrete details of post-college life in the workplace may allow students to make their major choice with more confidence. This paper provides an initial investigation in chemical engineering major selection and lays the foundation for future studies.

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