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First-Year Engineering Students' Perceptions of Engineering Disciplines: A Qualitative Investigation*

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In understanding undergraduate students' success in college, their choice of career path must be fully understood. Different paths are appropriate for different students, and even a student may not fully grasp what will work best for them. Understanding the mechanisms behind a successful choice in college major is important for several reasons. Retention is necessary for the continued health of engineering programs. One of the earliest steps in this career path is selecting a major. Research has been done investigating major selection across all majors, and even focusing on STEM careers. This research has frequently overlooked the broad variety present in engineering majors with very limited research conducted that distinguishes between one engineering major and another. This paper seeks to address this absence by surveying engineering students from several different majors at three different institutions. The data for this paper was gathered using surveys of first year engineers at three dissimilar institutions. The survey data examined were open-response questions. These questions asked students to describe how they viewed specific engineering career paths. It is the goal of analyzing these responses to gain better insight into the student perception of various engineering majors. The data was coded through an inductive coding process. This coding process resulted in nine unique codes. The codes were analyzed to allow broader trends to surface. The results of this analysis have shown that not only do students in different engineering majors view these disciplines differently, but also that students at these different institutions view engineering differently.

Keywords: major selection; qualitative; first-year engineering

1. Introduction

In Seymour and Hewitt's seminal work, "Talking About Leaving: Why Undergraduates Leave The Sciences," they recognize the selection of an engineering major as an "uninformed choice" [1], yet it is a critical decision that determines a student's educational and professional future. Studies have sought to better understand what factors may influence major selection. For example, a study by Brawner et al. [2] reported that the structure of a program influences major selection. Specifically, students that are in first-year engineering programs versus those in direct matriculation to engineering major programs showed differences in the majors they were most likely to select [2]. Students in first-year engineering programs were more likely to initially select mechanical, civil, and computer engineering and less likely to select chemical, electrical, or materials engineering than students in a direct matriculation to an engineering major program. Further, those students who began as undeclared in their engineering major were more likely to select mechanical, electrical, computer, and materials engineering as their initial major selection than direct matriculation students. The work by Brawner et al. [2] shows that students do demonstrate preference among engineering majors, and thus, they must perceive differences between them. However, what is not illuminated by this study, and those that are similar, is why these students chose these majors in the first place. There has been preliminary

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research into helping undergraduate students make a more informed decision. A study by Meyers describes the process of changing classroom methods to better inform students, however this yielded no statistically significant results [3].

1.1 Background

In examination of initial major selection, a study by Arcidiacono [4] found the major selection decision to be related to student academic ability. The study also addressed the long-term monetary implications for such a decision. Arcidiacono found that short term implications primarily drove the decision; the key factor was student academic interest for studying a particular major in college with a secondary motivation in student's interest in professional work. Additionally, high ability students (based on mathematics achievement) tend towards majors that result in more profitable professional pathways while lower ability students (based on mathematics achievement) tend towards "easier majors" [4]. Standardized test scores have at times been used to predict student success and retention [5]. Student expectations of future earnings, coupled with ability, have been found to be critical factors in choosing a college major; however, these perceptions are subject to critical errors [6]. In some instances, students incorrectly interpret the careers and wages of family members in lieu of objective data when considering future options [7]. A study exploring STEM attrition went beyond expectations of success to actually examine the college grades of students. This examination showed that grades in college can be a strong influence on retention for a STEM major [8].

In addition to interest and ability, identity is often reflected in research relating to major selection. Gender is recognized as a critical factor in major selection, and women have been found to pursue well paying, high-status occupations in STEM fields at a lower rate than men, with professional aspirations being formed during adolescence [9]. The background of a student has also been suggested to influence major selection: it could be argued that students with more privileged upbringings are less risk-averse [10]. Risk in this instance is defined as the possibility of failing in the major, thus making the natural science fields riskier than other fields, such as education or the liberal arts. The educational experiences in high school, according to several studies [11, 12], have the potential to strongly influence students in their choice of college major. Some research specifically studied STEM majors and the STEM resources in each school available to students. While curricular paths affected students of different genders and races differently, the data supports the hypothesis that an increase in STEM high school classes (including advanced-track options) increases the likelihood that a student will declare a STEM major in college [11]. Other research expanded the study to include post-secondary experiences that occur early on [12]. A study by Heilbronner discuss the conclusion that a student's belief in their own ability strongly influences whether that student will remain in a STEM field [13].

In engineering, identification with the field has been explored to better understand experience in engineering and persistence which both related to major selection broadly. For example, Meyers, Ohland, and Silliman [14] studied students and alumni responses to a survey finding that work experiences are significant factors related to seeing oneself as an engineer. However, we know that experiences alone are not enough to call oneself an engineer; self-identification as an engineer is extremely complicated and multifaceted [15]. It has also been shown that application of coursework to a broader context can increase student success and retention [16]. Our work looks to better understand these other factors focusing on the differences across engineer majors as there are unique differences between the disciplines within engineering.

1.2 Theory

A more comprehensive perspective for considering major selection is based on Social Cognitive Career Theory [17], which incorporates many of the aspects described previously into a single, unified theory. From this lens, career development is a process related to self-exploration and choice. However, there can be barriers to career pathways: "a complex array of factors such as culture, gender, genetic endowment, sociostructural considerations, and disability or health status operate in tandem with people's cognitions, affecting the nature and range of their career possibilities" [17]. The exploration and selection of an engineering major is often a focal point of first-year engineering programs, and this experience has been found to be "polarizing," either affirming a student's plans to study engineering (or a specific discipline) or dissuading them altogether [18]. Utilizing Social Cognitive Career Theory as a theoretical lens, data collected from students in first-year engineering courses from three dissimilar institutions were assessed in order to better understand how these students selected their engineering major.

2. Methods

This study involved open-ended survey question data collected from three institutions in the fall of 2014. An open coding approach was used to analyze the results. Once coded, the data was reviewed to develop trends related to students' understanding of engineers in the workplace. Details regarding the methods are provided below.

2.1 Participants

Three institutions participated in this study (U1, U2, and U3). U1 is a large Midwest public land grant institution. U2 is large Midwest public institution in an urban setting. U3 is a medium Midwestern public institution in an urban setting serving the most diverse student body of the three institutions. The participants were all first-year engineering students taking the first course in a two course introduction to engineering sequence beginning in fall 2014. At U1 the survey was sent to 2014 potential participants, at U2 it was sent to 1224 potential participants, and at U3 it was sent to 219 potential participants. The response rates for each institution were 46% (927 responses), 58.8% (720 responses), and 92% (202 responses) respectively. The overall response rate was 53.5%, which corresponds to 1849 responses. The response rates across institutions are presented in Table 1. It should be noted that these institutions range in size, which is reflected in the number of responses from each location. All of the surveys were administered as part of a course and in compliance with approved IRB protocols. At U1 and U2 participation in the research component of this work was completely optional, hence the lower response rates. At U3, the survey was part of the course assessment; however for research purposes, all responses were anonymous allowing the results to be used as existing educational data.

2.2 Survey

The survey was administered at all three institutions at the start of the academic year in the form of an electronic survey. The questions used for this study asked students to describe what an engineer in a specific discipline would do in the workplace. For U1, participants provided responses related to the engineering discipline they plan to pursue and provided responses for another engineering discipline of their choosing. At U2 and U3, participants were asked to comment specifically on what civil, chemical, electrical, and mechanical engineers do in the workplace. These fields were chosen by U2 because those four disciplines are specifically investigated through a series of hands-on experiments within the first-year engineering course taught at this institution. U3 chose these fields because those are the majors offered at this institution in engineering. U1 had to take another approach (having students comment on their planned major and another major in engineering) because there are 14 disciplines that students can choose to pursue, and it was not feasible to ask students to comment on all 14 disciplines.

Table 1. Survey Response Rates

Institution	Potential Respondents	Actual Respondents	Response Rate
U1	2014	927	46.0%
U2	1224	720	58.8%
U3	219	202	92.2%
Total	3457	1849	53.5%

2.3 Analysis

The open coding approach used for this study generally followed the recommendations of Patton [19] where the data was inductively examined to develop the codes. This approach was chosen to allow the codes and trends to emerge from the data set as opposed to checking the applicability of predefined categories. Since little research has been conducted about this topic, this approach is appropriate to establish a baseline understanding. The coding was completed by two researchers; however, a larger research team was involved in the code development and refinement.

To begin the analysis, 50 responses for two survey questions from U1 were analyzed to develop the initial codes. Each of the two researchers in charge of coding came up with a list of approximately 20 codes and corresponding definitions that summarized the selected responses. Following the initial coding, the two researchers met with two additional members of the research team to focus the codes. Based on this discussion eight codes with definitions were developed out of the lists.

Next, the first 100 responses for two survey questions were coded with the agreed upon codes. The coding between the two coders was compared to ensure consistency, and discrepancies in coding were discussed and some code definitions were adjusted to be more accurate. We used Microsoft Excel© to complete this analysis highlighting full cells with various colors so a formal and truly accurate inter-rater reliability cannot be reported as one could with a software tool such as NVIVO© or MAXQDA©. However, this round of processing occurred approximately five times until the code definitions were finalized for U1. This approach supports the trustworthiness of the data analysis developed for qualitative analysis [20, 21]. Once the codes were finalized, the remaining data from U1 was coded.

Following the U1 data, the U2 data was coded by discipline. Throughout the processes the codes were critically evaluated to determine if they needed to be adjusted based on the information from the new institution. Three codes were adjusted as a result of coding the U2 data. For example, the definition for *serving others* was changed from "Wishing to better the lives. . ." to "Wishing to protect or better the lives. . ."

Finally, the U3 data was coded. No adjustments were made. Once the coding was complete, the U1 data was reviewed to ensure that the revised codes were applied appropriately. Table 2 below includes the final codes in alphabetical order, their definitions, and sample excerpts from the surveys that represent typical responses that fall within the codes. Note, all quotes in this paper are provided in their original wording so any typos are straight from the original data.

Some of the codes above were used significantly more than others. To ensure that the codes were specific enough to capture one idea or complementary ideas, we reviewed the frequency of use for each code to determine if the code should be broken down into additional subcodes. Upon review, we determined that the codes were indeed focused demonstrating their saliency, opposed to broad nature; except for one code (originally called *research, design, and development*). That code encompassed multiple ideas and was broken down into *research and design* and *build, maintain, and improve* which are shown in Table 2.

After the coding was complete, the results were reviewed to identify trends. The researchers looked at the data within institutions and majors and looked across institutions and majors to identify the trends. All trends were discussed with the research team to ensure trustworthiness in the findings. The trends are discussed in the following section.

Table 2. Final Coding Scheme

Code	Definition	Sample Quote [Institution, Participant ID]
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.	"[. . .] A chemical engineer typically uses concepts of chemistry, physics and calculus to efficiently mass produce certain chemicals. The chemicals being created obviously depend on the industry in which they are being produced, but chemical engineers rely on certain methods and processes for extracting or converting the material they desire [. . .]" [U3]
Location	Including a specific place, company, or industry mentioned by name.	"A Materials Science and Engineering major could work with companies like Nike or Procter and Gamble to develop specialized fabrics or plastics with certain requirements." [U1]
Options	Using engineering as a means to a wide variety of ends (e.g., graduate school, law, management, etc.), areas of specialization within the field (e.g., prosthetics, software, green engineering, etc.), or acknowledgement of general versatility. This may be a statement about options or a list of different options.	"If we talk about a Mechanical Engineer, he can do anything and everything. He could be a part of a power company, in an aerospace field, can assist civil engineers for building infrastructure and also be a part of army by producing different types of weapons and vehicles. Basically he can work everywhere." [U1]
Problem Solving	Using logic to solve current issues.	"A civil engineer would have the ability to think critically about how different structures, such as bridges or roadways, and decide how to implement such projects in the most effective way. He or she would hopefully be able to heavily impact the workplace positively." [U2]
Process	Viewing engineering as a sum of its actions (i.e. a computer science engineer works with computers). Includes mention of specific tools or material.	"An Electrical Engineer could spend his time working with detailed circuitry and developing new technologies." [U2]
Research and Design	Engaging in the development or conceptualization of a product or process.	"An electrical engineer would be the person in a workplace who would work on designing machines and their electrical current. Also they would be able to design the electrical materials that go into new products." [U2]
Build, Maintain, and Improve	Engaging in the creation, construction, upkeep, and enhancement of a product or process to progress efficiency.	"A Mechanical Engineer will look into how something works, and then can come up with ideas for something else, or to improve what they are looking at." [U3]
Serving Others	Wishing to protect or better the lives of individuals or society as a whole.	"An environmental engineer could work to improve environmental factors, and help make the world safer and better." [U1]
Working with Others	Working with or leading a team on collaborative endeavors.	"A Chemical Engineer would also be part of a team in the workplace. Chemical Engineers would be responsible for many different duties and tasks in the workplace." [U3]

3. Results and Discussion

The results are presented and organized by trends within majors and trends within schools. For each item, we have provided an explanation of the observed trend along with sample quotes. The quotes have not been altered in any way from the information received from the participants in the surveys, and therefore, we have included [sic] in the quotes to denote the misspellings and direct word choice of our participants. For the items related to major trends, we have provided the participant institution. For the items related to institution trends, we have provided the major the participant is describing in the quote. It should be noted that the major they are describing may or may not be their intended major based on the way the surveys were designed, as described in the Methods section.

3.1 Trends between majors

There were several trends that emerged within the discussion of each major. When looking at the trends within each major, only chemical, civil, mechanical, and electrical were explored as these were the majors discussed at all of the institutions. In our presentation of the results, we supply a sample quote from each institution to demonstrate the breath across contexts of these codes.

The most common code for the chemical engineering statements was *process*, but *research and design*, and *build maintain and improve* were also commonly used. The fact that chemicals and materials are used in the field was specifically emphasized in the student responses. This can be seen in the following quotes:

> "A Chemical Engineer in the workplace could monitor the mixture of paint or even the chemicals in windshield wiper fluid for different companies. Also you could work with microchips and shrinking them down to different sizes." [U1].
>
> "Chemcial [sic] engineers deal with the use of chemicals in many aspects. Chemical engineers attempt to find the best way to use chemicals in order to make the best product." [U2].
>
> "My impression is that chemical engineers would synthesize materials using different compounds that would be of practical use to people. Examples would be a cleaning formula or a type of athletic wear." [U3].

For civil engineering the most common code was *research and design*. Students discussed how civil engineers work to design buildings and infrastructure. Students also mentioned the public and safety in their responses. Students said:

> "Civil Engineers are engineers who are responsible for creating roads, bridges, and other types of structures that are used frequently by society. It is also their job to make sure that all of the above mentioned examples are performing as expected, if not they are required to fix them. In a professional workplace, civil engineers would be the ones who would be able to address important issues and find solutions to them, similar to how they address other issues in their field." [U1].
>
> "A Civil Engineer could work as someone who designs highways and bridges, making transportionon [sic] more efficient. By building sturdier bridges more vehicles could drive across the bridge making it more efficient and safe. A Civil Engineer could also build commercial [sic] buildings such as hotels, restaurants, rest stops, casinos etc. Working with a [sic] architecture team to complete some of the hardest structural desings [sic] making a building possible. A very simple thing that a Civil Engineer could do is build residential buildings such as houses, ranches, condos, retirement homes, etc." [U2].
>
> "Civil Engineers design large infostructure [sic] in order to improve the lives and conditions for all people. They are also employed by many levels of government and companies." [U3].

Another trend among civil engineering that was not seen as frequently with the other majors was that civil engineers would be overseeing projects and people, which falls with the code *working with others*. The quotes above also demonstrate this idea by mentioning working with construction managers, architect teams, and with other civil engineers.

For electrical engineering, *process* was the most cited code. Students specifically mentioned circuits, wiring and other electronics in their responses. This trend can be seen below:

> "Create the inside of a computer, the circuits for a phone, a tv. Manage the electricity for a city, manage the electric parts of an oil company, basically anything that has to do with circuits and the inside of any electronic device. (Not counting all the programming that a computer engineer does)" [U1].
>
> "An electrical engineer is someone who may design circuits or microchips for larger machines that require these items such as maybe a car or a factory machine. They can do many things in regards to power sources and the design of power systems for machines." [U2].
>
> "Electrical engineers basically deal with anything electricity. They design the electrical systems that bring us light into our homes and circuit boards." [U3].

The last major that was explored between the schools was mechanical engineering. This major was typically seen as the most versatile major with the most employment opportunities upon graduation. As with the other majors, the *research and design*, and *build maintain and improve* were very common codes, but students focused on the improvement to previous designs and the drive of mechanical engineers to make things better and faster. The quotes below demonstrate this idea:

> "I think a mechanical engineer could also do a lot in the workplace. They can develop new tools to make machines work faster and better for any company in the world" [U1].

Table 3. Breakdown of Code Application by Major

	Count of Code Application			
Code	**Chemical Engineering**	**Civil Engineering**	**Electrical Engineering**	**Mechanical Engineering**
Applying Knowledge	6%	2%	2%	5%
Location	7%	3%	2%	3%
Options	9%	3%	7%	14%
Problem Solving	4%	2%	4%	4%
Process	25%	24%	52%	12%
Research and Design	19%	31%	13%	27%
Build, Maintain, and Improve	20%	23%	15%	29%
Serving Others	7%	5%	3%	3%
Working with Others	2%	8%	2%	3%

> "A Mechanical Engineer could design and develop new machinery, tools, equipment, engines, test new machines, etc." [U2].

> "Mechanical Engineers improve products, create and build new inventions and in a workplace they can improve efficency [sic] by making safer machince [sic]." [U3].

The overall breakdown of the code application by major is shown in Table 3 where each major sums to 100%.

3.2 *Trends between schools*

As the data was coded, trends differentiating the schools emerged. All three schools had high percentages of responses coded with *process*, *research and design*, and *build, maintain, and improve*. However, it is in the other six codes that we can see trends emerging between the schools.

U1, the large Midwest public land grant institution, had students interpreting the question through a wider variety of lenses discussing *applying knowledge, options, problem solving*, and *serving others*. While at U2 and U3 it was common to see students specifically discussing mechanical engineers when referring to the versatility of their degree (*options*), U1 students each thought their personal discipline afforded the most career options (another aspect of *options*). For example, two students, in biomedical engineering and computer science and engineering, provide parallel observations below. As mentioned above, the student identification is typically based on the field they are speaking about and not necessarily the one which the student is pursuing; however, these two quotes from U1 are from students who intended to enter these majors.

> "A biomedical engineer has a wide variety of options in the workplace. He or she could do anything from research, to working on medical machinery, to developing a new drug. A biomedical engineer could be sitting at a desk all day, in the field all day, or anywhere in-between. The flexibility that biomedical engineering offers is what excites me most about the field." [U1, Biomedical Engineering]

> "Computer Science and Engineering engineers are probably one of the most versatile engineering archetypes. The field is the newest, arguably, and is constantly changing. So very many roles, ranging from straight coding to creating tools to utilize them as the primary motive to studying how any of that is possible, are commonplace. Honestly, I only interpret them as a catch-all, delving into whatever they see fit, and making sure they have the proper teams with them." [U1, Computer Science and Engineering].

Additionally, students at U1 were more focused on their career goals. This may manifest as aspiring to work for a specific company (*location*), attain a certain education level, or even transform an industry. This could have been caused by the nature of the questions at U1, where students provided thoughts on their intended major rather than on a common set of majors. Students will most likely have spent more time investigating and thinking about the major they intend to pursue, and thus, may have a clearer understanding of the field and what they hope to accomplish. Two such views are below.

> "[. . .] I am most interested in the biomechanics aspect of this field. I would love to someday be doing orthopedic research in things like innovating sports surgeries or developing new training procedures for athletes to reduce injuries. I also am interested in working in the technology area of this field developing better instruments to evaluate patients that physicians and techs can use." [U1, Biomedical Engineering]

> "I want to work on light bulbs, that's my thing. I visited GE and shadowed some engineers, and ever since then I have wanted to work on electronics and lamps. I could work on advancements with LED lighting and beyond." [U1, Electrical Engineering].

At U2, the large Midwest public institution in an urban setting, the only code used frequently outside of the top three was *options*. However, all the other codes were used. Students showed a sense of responsibility to keep the public safe (*serving others*) while still maintaining the integrity of a finished product. Across many majors, this duty to protect both company affiliates and civilians was felt to be vital in product design and process improvement. This is apparent in the following quote:

> "[. . .] They could design rollar [sic] coasters and make them more thrilling and dangerous but still safe. A Mechanical Engineer could design better safety measures for a car such as an airbag that deploys a certain way or seatbelts that can handle more tension. They could design cars that run longer without breaking down or cylinders that have a better compression ratio to make the car go faster etc." [U2, Mechanical Engineering]

Additionally, U2 students emphasized their own potential to manage teams and demonstrate leadership (*working with others*). There seemed to be a sense that though a career may begin with engineering, it will eventually turn toward a more coveted management role. One such student who exemplified this trait is shown below.

> "This is the type of engineering that I am planning to pursue and exited to do so. So, my image of the civil engineer would be someone who deals more with structures and bridges as as [sic] whole opposed to say material where they look at just the steel or etc. the civil engineer I believe will be reviewing, inspecting, and evaluating the whole of it. the civil engineer may begin physically working on structures with inspections and then work their way to a position that manages and oversees structures and what goes into evaluating them and even creating them." [U2, Civil Engineering]

Finally, U2 seemed to find the optimization of processes as an essential goal regardless of major. For example, this student discussing mechanical engineering viewed the increase of company profit as the realistic and worthwhile job of a mechanical engineer:

> "They could work to make improvements to efficiency on a mechanism to lower the production cost of an item and, in turn, raise profits." [U2, Mechanical Engineering]

U3, the medium Midwestern public institution in an urban setting, had students who stood out for showing some confusion about the role of engineers. Mechanical engineers were frequently compared to mechanics with a more thorough knowledge of physics for example, which is not entirely surprising given the blue-collar nature of the U3 surrounding area. U3 offers five engineering disciplines: chemical, civil/environmental, computer/electrical, industrial systems, and mechanical engineering. Yet, misunderstandings abounded among these first-year students. Compared to the other schools, U3 students were also the most likely to decline to answer the question, citing lack of knowledge. Some examples of such responses include:

> "Mechanical Engineers make blueprints and designs for just about anything." [U3, Mechanical Engineering]

Table 4. Breakdown of Code Application by Institution

Code	Percentage of Code Application		
	U1	**U2**	**U3**
Applying Knowledge	5%	4%	3%
Location	4%	4%	3%
Options	17%	7%	5%
Problem Solving	7%	3%	3%
Process	24%	26%	27%
Research and Design	19%	25%	24%
Build, Maintain, and Improve	16%	24%	28%
Serving Others	7%	4%	5%
Working with Others	3%	4%	3%

> "Civil Engineering would be the field that I am least informed about so I couldnt [sic] tell you." [U3, Civil Engineering]

Students from this school were also the most likely to list *process* answers by mentioning specific actions those in the engineering discipline perform. One typical response of this type is:

> "Civil Engineers use excell [sic] and other tools to calculate what materials and how much of a material is necessary to build a structure as well as designing frames to hold a structure together." [U3, Civil Engineering].

The overall breakdown of the code application by institution is shown in Table 4. All majors and responses are included in this table.

4. Conclusions and future work

Through this research, we were able to explore first-year students' initial conceptualizations of different engineering disciplines across three institutions. The results serve as a starting point for future investigations into engineering students major selection choices within the first year and beyond.

4.1 Conclusions

The main codes found across the responses were *process*, *research and design*, and *build, maintain, and improve*. This is promising to see as design and creation are the quintessential activities associated with engineering. That students were able to identify these as a major component of engineering practice in the workplace demonstrates that a significant percentage of incoming students have some knowledge of what engineering is and what engineers do. Whether they understand the nuances of each specific discipline or not is one of the reasons to include first-year engineering courses.

Beyond the three most common codes, the largest difference is related to mechanical engineers having the most *options*. Mechanical engineering tends to be viewed as a broad discipline opposed to a discipline such as civil engineering. This could be due to the work of mechanical engineers or the marketing of the discipline that students receive.

The differences present among the coding for the different institutions are more intriguing. For example, U1 offers the widest variety of engineering degree options. Based on this, the students at U1 may be more knowledgeable in the *options* they have available, both while at U1 and upon completion of their degree. Another difference between U1 and U2 is that at U1, all students enter as first-year engineering students and matriculate to their degree programs following the completion of their first year. At U2, the majority of students (~80%) matriculate directly to a degree program. This freedom to explore different engineering fields once at university may also attract more students who view engineering through the *options* it affords them.

U3 serves the most diverse student body of the three institutions in terms of race/ethnicity and socioeconomic status. We suspect that this diversity also plays a role in U3 students' conceptualizations of engineering as being more trade focused (i.e., the references to mechanics). Further investigation into these students' exposure to engineering and engineers is needed to fully understand how diversity affects the responses.

4.2 Future work

Now that we have established a baseline understanding of students' views of different engineering disciplines, we will explore how these conceptualizations change over the first year and beyond keeping in mind that career development is related to choice but also self-exploration as defined by Social Cognitive Career Theory. We expect that the codes and their definitions will remain relatively consistent over time; however, we believe that as students develop into engineers, we will note more differences in the distributions of the codes, especially across the different disciplines and potentially across genders. As students gain a deeper understanding of their chosen field, we suspect that we will see a great disbursement of codes and can begin to better understand how students view the fields differently.

References

1. E. Seymour and N. M. Hewitt, *Talking about leaving: Why undergraduates leave the sciences*, Westview Press, 2000
2. C. E. Brawner, M. M. Camacho, R. A. Long, M. W. Ohland and M. H. Wasburn. Work in progress-the effect of engineering matriculation status on major selection. In *Frontiers in Education Conference, 2009. FIE'09. 39th IEEE*, San Antonio, Texas, October 2009, pp. 1–2.
3. K. L. Meyers, A Course to Promote Informed Selection of an Engineering Major Using a Partially Flipped Classroom Model, *Journal of STEM Education*, **17**(3), 2016, pp. 14–21.
4. P. Arcidiacono, Ability sorting and the returns to college major, *Journal of Econometrics*, **121**(1), 2004, pp. 343–375.
5. W. C. Leuwerke, S. Robbins, R. Sawyer and M. Howland, Predicting Engineering Major Status From Mathematics Achievement and Interest Congruence, *Journal of Career Assessment*, **12**(2), 2002, pp. 135–149.
6. P. Arcidiacono, V. J. Hotz and S. Kang, Modeling college major choices using elicited measures of expectations and counterfactuals, *Journal of Econometrics*, **166**(1), 2010, pp. 3–16.
7. X. Xia, Forming wage expectations through learning: Evidence from college major choices, *Journal of Economic Behavior & Organization*, **132**, 2016, pp. 176–196.
8. K. Rask, Attrition in STEM Fields at a Liberal Arts College: The Importance of Grades and Pre-collegiate Preferences, *Economics of Education Review*, **29**, 2010, pp. 892–900.
9. S. L. Morgan, D. Gelbgiser and K. A. Weeden, Feeding the pipeline: Gender, occupational plans, and college major selection, *Social Science Research*, **42**(4), 2013, pp. 989–1005.
10. C. Montmarquette, K. Cannings and S. Mahseredjian, How Do Young People Choose College Majors? *Economics of Education Review*, **21**(6), 2002, pp. 543–556.
11. M. C. Bottia, E. Stearns, R. A. Mickelson, S. Moller and A. D. Parker, The Relationships among High School STEM Learning Experiences and Students' Intent to Declare and Declaration of a STEM Major in College, *Teachers College Record*, **117**(3), n3, 2015.
12. X. Wang, Why Students Choose STEM Majors: Motivation, High School Learning, and Postsecondary Context of Support, *American Educational Research Association*, **50**(5), 2013, pp. 1081–1121.
13. N. N. Heilbronner, Stepping Onto the STEM Pathway: Factors Affecting Talented Students' Declaration of STEM Majors in College, *Journal for the Education of the Gifted*, **34**(6), 2011, pp. 876–899
14. K. L. Meyers, M. W. Ohland and S. E. Silliman, How self-identification and views of engineering change with time: A study of students and professionals. *International Journal of Engineering Education*, **28**(1), 2012, p. 103.
15. K. L. Meyers, M. W. Ohland, A. L. Pawley and C. D. Christopherson, The importance of formative experiences for engineering student identity. *International Journal of Engineering Education*, **26**(6), 2010, p. 1550.
16. J. K. Bartley, Making Chemistry Relevant to the Engineering Major, *Journal of Chemical Education*, **87**(11), 2010, pp. 1206–1212
17. R. W. Lent, S. D. Steven and G. Hackett. Social cognitive career theory, *Career Choice and Development*, **4**, 2002, pp. 255–311.
18. K. L. Meyers, G. W. Bucks, K. A. Harper and V. E. Goodrich, Multi-Institutional Evaluation of Engineering Discipline Selection, *ASEE Annual Conference & Exposition*, Seattle, Washington, June 2015, p. 24512
19. M. Q. Patton, *Qualitative Research and Evaluation Methods*, Sage Publications, Thousand Oaks, California, 2002.
20. M. B. Miles and A. M. Huberman, *Qualitative Data Analysis: An Expanded Sourcebook*, Sage Publications, Thousand Oaks, California, 1994.
21. J. W. Creswell and V. L. P. Clark, *Designing and Conducting Mixed Methods Research*, Sage Publications, Thousand Oaks, California, 2007.

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