

Why Students Select the Civil Engineering Major

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Abstract

Understanding why students select their intended major can help faculty to motivate and retain those students in a program of study. Ensuring that students remain motivated by their educational program greatly increases the likelihood that they will successfully complete the major.

The study presented within this paper used a course-generated student essay that reflects on why students at a particular academic institution selected the civil engineering major. The essay assignment has been used over multiple course administrations during a five-year period. Essays were reviewed for reference to a series of nine specific motivations for selecting the academic Students at the United States Military Academy (West Point) select their academic major during the spring of their first year. They start coursework in their major during the fall semester of their second year. One of the first courses that students take when majoring in the civil engineering program is CE201, Introduction to Civil Engineering. CE201 is a required 1-credit hour course in the civil engineering curriculum. Other than students that transfer into the major late, all students take it as part of their first semester in the program. The collected data has been evaluated to look for trends in major selection reasoning, as well as differences between genders.

This study will be of interest to faculty and administrators with a desire to understand the motivation behind their students' major selection. The results of this study have the potential to significantly impact the activities and areas of emphasis used during recruitment of students to the civil engineering major.

Background

As the name implies, this seminar-based course introduces students to the civil engineering profession through discussions covering a range of topics including: the engineering design cycle, required components of a profession, Codes of Ethics, and sustainability. The course was first incorporated in the curriculum during the fall semester of 2018, and it has been delivered every fall semester since. The course is delivered by a team of two or three instructors. The same group of instructors has not been in place throughout the five years. Enrollment in the course has averaged 42 students per semester.

One of the writing assignments in CE201 requires students to write a 2–3-page paper addressing the question: “Why did you choose to major in civil engineering?” This prompt has remained unchanged during the five years that the course has been delivered. While grading of the assignment focuses on traditional aspects of written work including substance, organization, style, mechanics, and documentation. A secondary aspect of the assignment, that is not graded, is the opportunity to record the cited reasons why students select the major. A series of nine motivation areas were established and a tracker was used to record each category individual students mentioned in their graded paper. That same tracker, using the same nine motivation areas, has also been unchanged during the years the assignment has been administered.

In the first three years that the essay was incorporated as an assignment, students turned in a paper-copy, the assignment was graded, data was collected, and the essay was returned to the student. In the most recent two years that the course was administered, the essay was submitted in electronic format. Accordingly, a repository of two years of original student papers are included in the available data set.

The paper’s authors initiated this study with the following research questions:

- *Are there notable trends in the reasons students use to explain why they opted to pursue a degree in civil engineering?*
- *Are there differences between male and female reasoning when explaining why they opted to pursue a degree in civil engineering?*

Statistical analysis was used to identify trends in reported reasons for selecting the major. Discussion related to the potential reason for observed trends is presented herein.

Literature Review

Much has been written about why students choose their college major. Zahorian et al [1] conducted a survey over four years consisting of an average of 300 students per year to determine why they chose their major. Students were asked about the degree to which each of 11 factors contributed to their final choice of major. The authors described that four factors emerged as the most significant: “(1) major already chosen before beginning to explore engineering course; (2) perceived societal impact of chosen major; (3) personal interests most closely align with chosen major; and (4) perceived job prospects in chosen major.” Anderson-Rowland et al [2] surveyed 189 students asking why they had selected engineering disciplines. The top results : money, like math/ science, exciting, many job opportunities, and challenging as shown in Figure 1.

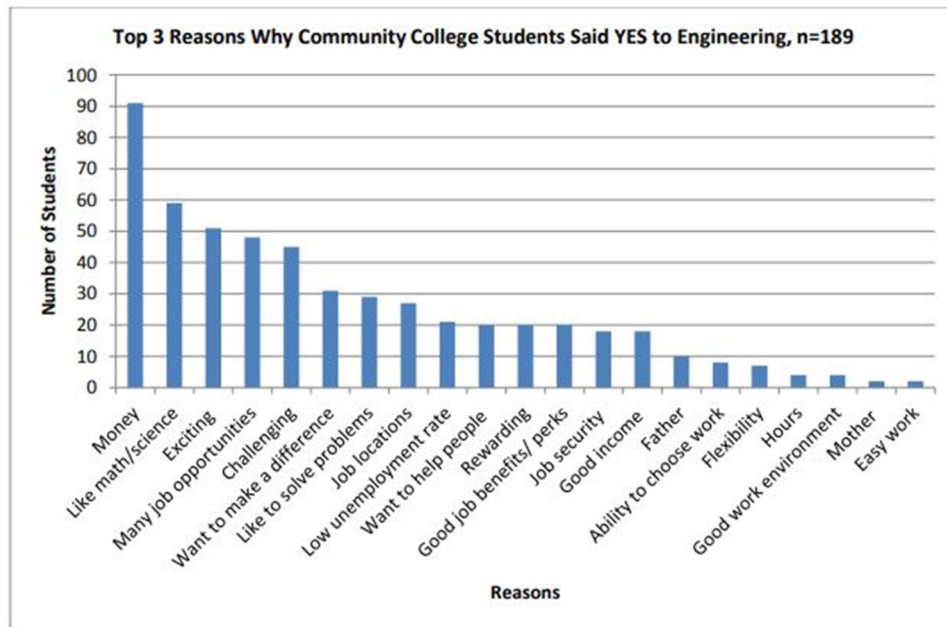


Figure 1. Reasons Students Chose Engineering Majors, after Anderson-Rowland et al [2]

Ngambeki et al [3] surveyed 974 first year engineering students as to why they chose their majors, and among civil engineering students, the most common reasons cited were that: “this discipline gave them the opportunity to work outdoors and the chance to work with their hands building things. Other reasons included an enjoyment of structural design, being able to immediately see the fruits of your labor, previous positive experience with construction work, and the attraction of building something with longevity.” Painter et al [4] surveyed 390 first-year engineering students and found that the top three reasons the participants identified for selecting a major in engineering were “interest, family influence, and prior experience with something related to engineering. The least frequent responses included helping society, engineering as a means to an end, and a desire for a challenge.” It should be pointed out that there is much discrepancy between the various studies, where “family influence and challenging experience” rank high on some studies and low on others.

Matusovich et al [5] conducted a longitudinal study to investigate why students chose engineering as a major, and to determine if they were likely to remain in the major through graduation. They concluded that students’ personal values and sense of self were significant factors in choice of major and retention. They further concluded that “to increase persistence rates we must focus on values, especially by helping students connect their personal identities to engineering identities.”

A large number of researchers have conducted a focused investigation of why female students select engineering or a subdiscipline of engineering, and their findings suggest varied motivations for both male and female students’ major selection. The Extraordinary Women Engineers Coalition [6] conducted extensive surveys and focus groups with female high school students and college engineering students and found that most high school students and their parents, as well as other identified role models did not really understand what engineers do and were not motivated by what the profession of engineering recommended as reasons to pursue engineering. Cruz and Kellam [7] conducted in-depth interviews with 21 engineering students, including seven female students, in several programs and synthesized their findings through the perspective of the narrative arc of classic adventure stories. They found that high self-efficacy in math and science and a background in tinkering with engineering toys or projects earlier in their education were among the strongest motivators to choose a major in engineering. Smith [8] conducted in-depth interviews with a small cohort of female engineering students to determine their motivations for studying engineering; the study identified strong self-efficacy in mathematics and science and the suggestion of family and friends as the most important influences, but only one of the 17 interviewees had chosen civil engineering as a major and thus it was not possible to contrast civil engineers’ motivations with those of students studying other engineering disciplines.

MacDonald and Durdyev [9] found that friends’ and family members’ influence did not strongly affect female students’ propensity to study the civil engineering adjacent fields of “architecture, engineering, and construction studies.” Jacobs et al [10] conducted focus groups on women in STEM and engineering disciplines and found that “fathers and math teachers play in the choices

women make to study engineering,” although this influence affected both students' decisions for and against majoring in engineering.

Bronzini et al. [11] used market research techniques to determine that the general public's lack of exposure to civil engineering was a significant challenge to recruiting students, and they reported contact with civil engineering role models as the single most important influence on students' choices to pursue studies in civil engineering, with equal or greater influence on women or ethnic minorities. Shealy et al [12] found that while male and female students were both strongly motivated by environmental sustainability concerns to choose civil engineering as a major, female students were significantly more likely to cite concern for social issues such as addressing poverty and opportunities for underrepresented groups. Ohland et al [13] built on significant prior work with other engineering disciplines to investigate degree trajectories and persistence of various demographic groups for students studying civil engineering.

Methodology

The data used in this study was generated during a review of an essay assigned to all students enrolled in CE201 over a five-year period. The essay prompt remained unchanged during the five separate administrations. During the process of grading the students' reflective essays, the grader made note of the students' self-reported motivations for selecting the civil engineering major. Even though the course is team-taught, for consistency a single instructor graded the essays and it was this instructor who recorded student responses in each of the nine motivation areas. The same instructor graded essays across the first three years of the study. A different instructor graded essays during the fourth and fifth years of the study.

As noted previously, during the first three years essays were collected in hard copy. In the most recent two years, essays were collected as electronic submittals. Across all five years the points allocated to this assignment were 100 out of the total course points of 667. As a 1-credit, seminar-based course there are only a handful of out-of-class assignments and most involve reflective writing activities. Prior to submitting their essay, students exchanged papers and provided one-another with a peer review. Essays were revised based on peer-feedback and then were turned-in for grading. Students were not aware that their essays would be analyzed relative to the nine motivation areas.

During a review of the essay produced by the first cohort of students, the grader generated a list of the most common motivations to the prompt. A total of ten different motivations were identified in the first administration. Those same ten motivations have been used in all subsequent essay reviews. The ten response areas used were:

- Challenging,
- Family/mentor influence,
- Hands-on opportunities,
- Help society,
- Interested in what civil engineers do,
- Job opportunities.
- Knew before coming to academic institution/experiences as a child/youth,
- Open house,

- Learn useful skills – critical thinking and problem solving, and
- Program quality/reputation

Most of the identified motivations areas are likely self-explanatory. Motivation areas were not dependent upon any specific key word or phrases. Rather, fairly broad interpretation of a student’s writing was used to record associated motivation areas. While some students may have only written a reflective essay that touched on a single motivation area, others frequently mentioned more than one motivation area and were recorded accordingly.

Students were coded by gender as either male or female in accordance with the gender identification listed in their student records. No attempt was made to code individuals in the data set as anything other than male or female. The students’ responses were organized in a spreadsheet which used indicator variables for each of the motivations they mentioned. In other words, if a student listed “Help society” as a motivation, then this variable would be 1; otherwise, the variable would be 0. Student responses generally included several motivations. The dataset considered five years of data and contained 193 students in total. The analysis computed motivation indicators as a percentage of the population. Changes in these percentages were evaluated with respect to class year and gender.

Results

The students’ motivations over time are shown in Figure 2. The percentage of populations are computed as the sum of the votes for each motivation divided by the population size for the year. Each of the ten motivations are indicated by different colored bars in the plot. Tables 1 and 2 list the top three, and bottom three, motivators reported for each year. Figure 3 shows the percentage of motivations reported split by student gender. The percents are computed as the sum of the votes for each motivation for all five years divided by the gender’s population. The dataset was comprised of 31 female students (16%) and 161 male students (85%).

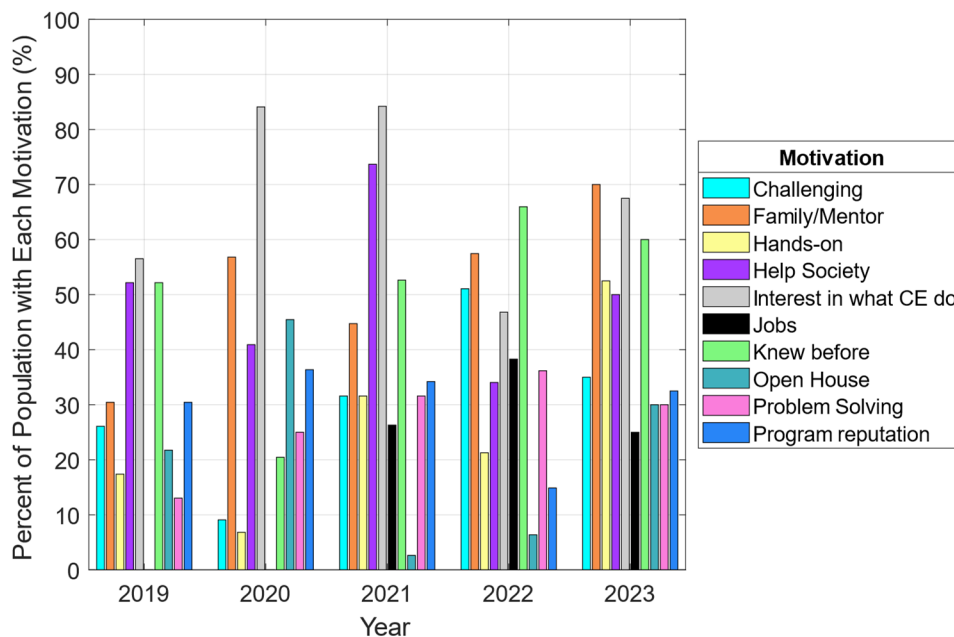


Figure 2. Motivations for choosing the CE major per class year.

Table 1. Top three choices of students per year. The vote percentage is the number of total votes a motivation received divided by the year's population (N). This table shows the motivations with the highest vote percentages in Fig. 2.

Year	Rank	Motivation	Vote (%)
2019	1	Interest in what CE do	56.5
N=23	2	Knew before	52.2
	3	Help Society	52.2
2020	1	Interest in what CE do	84.1
N=44	2	Family/Mentor	56.8
	3	Open House	45.5
2021	1	Interest in what CE do	84.2
N=38	2	Help Society	73.7
	3	Knew before	52.6
2022	1	Knew before	66.0
N=47	2	Family/Mentor	57.4
	3	Challenging	51.1
2023	1	Family/Mentor	70.0
N=40	2	Interest in what CE do	67.5
	3	Knew before	60.0

Table 2. Bottom three choices of students per year. The vote percentage is the number of total votes a motivation received divided by the year's population (N). This table shows the motivations with the lowest vote percentages in Fig. 2.

Year	Rank	Motivation	Vote (%)
2019	10	Jobs	0.0
N=23	9	Problem Solving	13.0
	8	Hands-on	17.4
2020	10	Jobs	0.0
N=44	9	Hands-on	6.8
	8	Challenging	9.1
2021	10	Open House	2.6
N=38	9	Jobs	26.3
	8	Problem Solving	31.6
2022	10	Open House	6.4
N=47	9	Program reputation	14.9
	8	Hands-on	21.3
2023	10	Jobs	25.0
N=40	9	Problem Solving	30.0
	8	Open House	30.0

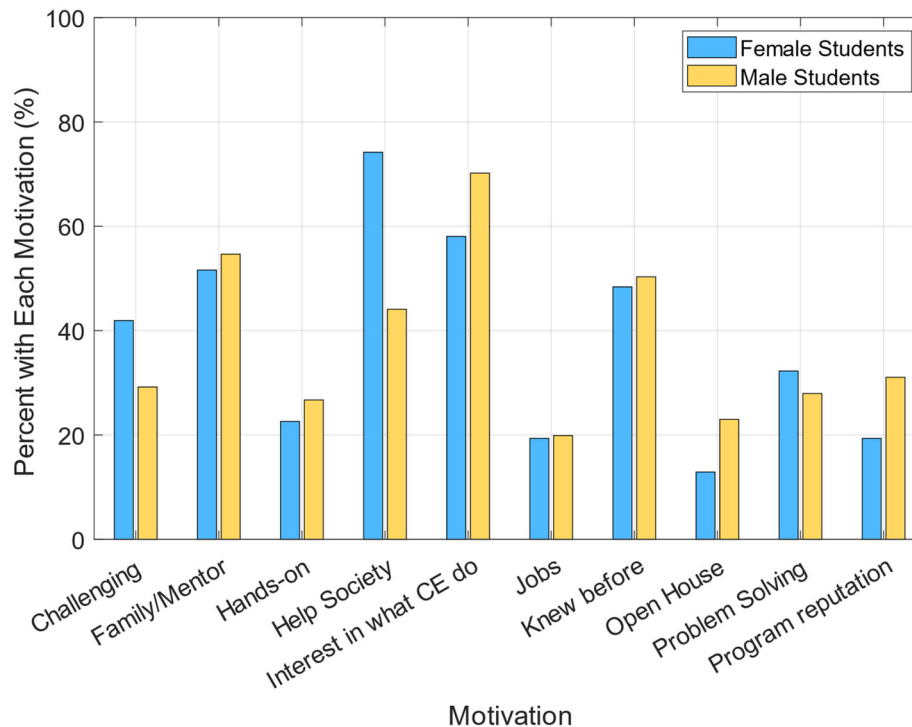


Figure 3. Prevalence of motivations for choosing civil engineering major among female and male students.

Discussion

The motivations for the study population (Figure 2) show that *interest in the discipline*, *exposure to family/mentors*, *knew before* (i.e., had already made the decision to select the major), and *help society* drive the selection process towards civil engineering for the respective academic major. A review of the top three ranking motivations for each year group (Table 1) highlights that these are ever present even though they tend to trade places in the rankings from year to year (with the exception of *help society* only ranking in the top three in 2019 and 2021). This pattern is not surprising given that prior research highlights these influential factors across all disciplines [1].

However, in contrast with prior research, *jobs* (or *job prospects*) does not show up as a significant motivation. Except for the 2022 data set, this factor repeatedly shows in the three bottom-ranking motivations chosen by the study population (Table 2). A potential explanation for this phenomenon is the fact that the students at this particular institution have guaranteed employment upon graduation. As a military academy, West Point places every graduate as an officer in the United States Army for a minimum period of five years. It is likely that this established employment pathway negates the desire for the students to select their respective majors based on employment potential. Nevertheless, the authors have a reasonable expectation that this factor at other institutions likely continues to play an important role.

Regardless of the impact of this motivation at other institutions, the general apathy towards it among the prospective students at West Point highlights that recruiting efforts from the civil engineering faculty should focus on the other factors when communicating with prospective civil

engineering students (as all students at West Point select their academic majors after the first semester of classes). Likewise, the data also show that various other recruiting efforts and themes, commonly practiced by the civil engineering faculty at this institution, do not necessarily have the cost-to-benefit ratio to justify the current level of effort. The *open house*, *program reputation* and *problem solving* factors have shown waning importance to the study population (Figure 2, Table 2). As these themes are regularly communicated in the faculty's recruiting efforts, it is likely more effective to focus on the motivations that commonly show up in Table 1.

Lastly, another important point to highlight is the prominence of *help society* as an influence factor that leads female students to select civil engineering as an academic major at West Point. Prior research highlights the potential societal impacts of a major and profession as a strong motivator for women to select it [12]. The results of the current study indicate that the female respondents overwhelmingly list *help society* as a motivating factor (Figure 3). Albeit with a small sample size, the impact of this motivation (nearly twice the impact with female students than male students) shows that knowledge of the societal impacts and benefits from civil engineering could be the key to recruiting a larger population of female students into the discipline.

Conclusions

With the exception of 2022, *interest in what Civil Engineers do* was a top three motivation throughout the study. With the exception of 2020, *knew before coming to academic institution/experiences as a child/youth* was also a top three motivation. At West Point, the unique nature of the population is likely the reason why the *job* motivation was consistently low throughout the data set.

The female students represented in the data set were much more likely than their male counterparts to be associated with the *help society* motivation. This appears to align well with the literature cited in this study.

The conclusions reached during this study are associated with a unique population of students located at West Point who have selected to pursue their studies at a military academy. The ability to generalize to a broader population of civil engineering students or even more broadly to engineering students in general, may be limited. Although not investigated in this study, it is plausible that students at a military academy may select their academic major based on motivations that differ from their peers at other more traditional academic institutions.

The strength of the conclusions in this statistics-based study are limited by the size of the population. Replicating this study over a longer period of time would assist with strengthening conclusions related to trends but the year-to-year population size will make it challenging to make definitive claims about specific year-groups.

This study looked at the influence of gender on the reasons for selecting the civil engineering major. Females are slightly under-represented in the study's population in comparison to national enrollment data for civil engineering. It was not the intent of this study to further investigate additional demographic influences.

The authors are interested in pursuing additional research questions by using the same data set supplemented with additional years. In particular an additional study looking at the available electronic copies of student essays using keyword search software would assist in understanding specific reasoning behind student motivations.

The views expressed in this work are those of the authors and do not necessarily reflect the official policy or position of the United States Military Academy, Department of the Army, DoD, or U.S. Government.

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