A Question of When Students Select the Civil Engineering Major

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Abstract

On 15 November 2021, the Infrastructure Investment and Jobs Act (IIJA) became public law, providing $1.2 trillion of new funding for all 17 categories of infrastructure detailed in ASCE's Report Card for America's Infrastructure [1]. While the passage of this law was a needed investment into our infrastructure's safety and improved resilience, it highlighted a glaring gap in the U.S. engineering and construction workforce. Some estimate that the design and execution of infrastructure under the IIJA will require 82,000 additional engineers [2]! The U.S. Bureau of Labor Statistics published employment for civil engineers will grow by 6 percent over the next ten years [3]. Universities must attract and develop more civil engineers to meet the needs of society! However, with only 24% of high school seniors in the U.S. proficient in mathematics and 22% proficient in science [4], civil engineering programs at universities must be intentional about investing both time and resources to attract top talent from a small pool. Further, programs within each university are often fighting for talent as university resources (funding, staffing, and space sharing), especially for those in financial stress, are often tied to the number of students within each program. Thus, for a number of reasons, it behooves academic departments to invest in the process of recruiting students to their programs. Developing an understanding of why students choose a particular academic major and when students make their academic major decisions is helpful for departments to ensure they are investing in effective recruiting activities and the timing of those activities.

Multiple studies have been conducted to investigate the various factors that influence the "why" behind a student's choice of academic major. Many of those studies have focused on the choice of engineering as an academic major. A prior investigation by the authors of the current study looked at the specific factors that lead students to selecting the civil engineering major. While the "why" of selection has been extensively studied, the timing, or the "when," has not been previously investigated within the civil engineering discipline and has seen only limited study within more broadly focused choices of academic major.

This paper will be of interest to all civil engineering programs who want to ensure that they appropriately time their recruiting efforts to maximize student enrollment.

Introduction

A prior study conducted by the authors and others investigated why students select the civil engineering major at the United States Military Academy (West Point) [5]. The results of that study showed that students tended to select the civil engineering major as a result of one or more nine unique motivations (e.g., family influence, employment opportunities, etc.). One variable not considered in the prior study was the timing of students making their academic major selection. Thus, the current study looks specifically at the timing behind the decision to major in civil engineering. The research question investigated in this study is "when do students at the United States Military Academy select the civil engineering program as their academic major?"

While the students, as well as the selection process at West Point are unique to that location, it is anticipated that the results of this study will be of interest to any academician involved with the process of recruiting students to their engineering major. Further, the civil engineering industry will have a similar interest in this study as the primary stakeholders who are currently in need of more civil engineers. At most academic institutions, resources, including funding, are often linked to enrollment. Therefore, the ability to better understand the timing behind the selection of academic major can help inform when, where, and how departments engage with prospective students.

Background

Students at West Point declare their academic major during the second semester of their freshman year. Each academic department participates in a series of two majors fair events. The first majors fair occurs mid-way through the first semester of the freshman year, and the second majors fair occurs relatively early in the second semester of the freshman year. Freshmen are strongly encouraged to attend the fall semester event and are required to attend the spring semester event to learn about potential academic majors. During each majors fair event, every academic major is allotted two classrooms worth of space in a common academic building. Departments populate each classroom with displays, faculty members, and students currently enrolled in the program. The majors fair is typically two hours in duration which affords plenty of time for students to visit and learn about multiple academic departments. Students are free to declare their intended academic major beginning at the time of the second majors fair and must select a major within the following three weeks. During that three-week window, students are encouraged to meet with faculty, engage with current students, and even observe classes within the academic programs in an effort to help them make an informed decision. Undeclared is not an option. Declaring an academic major is accomplished by completing a simple form. For all academic majors, coursework is then started during the fall semester of the sophomore year.

Civil engineering enrollment at West Point has varied between roughly 30 and 55 students over the past 10 years. CE201, Introduction to Civil Engineering is a semester-long, 1-credit course that is intended to introduce students to the civil engineering profession and their chosen major. This is accomplished through discussion topics, including the engineering design process, aspects of a profession, codes of ethics, sustainability, and technology. CE201 was added to the civil engineering curriculum during the fall of 2018 and has subsequently been offered every fall semester. As a required course in the civil engineering curriculum, it is commonly taken during a student's first semester in the program, but occasionally it is taken later by students who transfer into the program late. The course is typically team-taught by 2-3 instructors.

There are multiple writing assignments within CE201. One reflective essay requires students to write about their process of selecting the civil engineering major. In a 2–3-page paper, students are prompted to write about when and why they selected civil engineering. The "why" was previously investigated, and findings were disseminated via conference proceedings [5]. The current study attempts to understand the "when" aspect of the students' decision-making process.

Literature Review

Much research has been conducted to investigate why college students select to major in engineering. For example, Matusovich, Streveler, and Miller [6] used an expectancy-value theory in a qualitative, longitudinal study of students' choices to both enroll and persist in engineering. That study found correlations between persistence and personal identity. Ngambeki et al. [7] conducted a survey of 974 first-year engineering students investigating why students selected engineering majors. Among the subset of civil engineering students in that study, the most common response was, "this discipline gave them the opportunity to work outdoors and the chance to work with their hands building things." Painter et al. [8] used a social cognitive career theory to survey 390 first-year engineering students, and they reported the top three reasons for selecting an engineering major as interest in math, family influences, and prior experiences. While many other engineering-specific studies of why the engineering major was selected have been published [9 – 13], a prior study by Graves et al. [5] was the impetus behind the current study. In their study, Graves et al. reviewed 192 reflective essays on the topic of why students specifically selected the civil engineering major. That study identified interest in the discipline, family influences, and a desire to help society as the top motivations for selecting the civil engineering major.

Some studies indirectly found evidence of when students select engineering while investigating why students select engineering. For example, Zahorian et al. [14] conducted a survey of nearly 1200 students during a four-year period to determine why they chose their major. Their number one most commonly reported reason was "major already chosen before beginning to explore engineering courses." Main et al. [15] conducted a mixed methods study that identified various social influences that resulted in the selection of an engineering major, and then they grouped those influences into pre-high school, high school, and first year of college. Cruz et al. [16] interviewed 21 students and identified various causes that motivated the students to select an engineering major and also captured the students' beliefs about engineering as they started their studies. Many of those "causes" were identified as occurring pre-college. The aforementioned study by Graves et al. also identified "knew before selecting the major" as one of the top reasons why students selected civil engineering.

Patterson et al. [17] conducted a study that looked at the timing of experiences in relation to the selection of academic major. Specifically, they investigated the influence of enrollment in courses during the semester that the academic major was declared, and they found a particularly strong correlation. Notably no literature was identified that specifically looked at just the timing behind the decision to select engineering as a field of study.

Methodology

All assignments in CE201 are submitted in electronic format, graded, and returned electronically. Thus, a repository of past assignments for this course exists. Essays for the fall of 2024 and fall of 2025 were used in this study. Each essay was individually reviewed, and notes were recorded whenever the student mentioned aspects of when they made their decision of academic major. Common responses of "before I arrived on campus," "during the majors fair," and "after

speaking with upperclassmen" were noted, which allowed grouping of responses. Even though the course is team-taught, for consistency, a single investigator reviewed each essay and coded it accordingly. No specific keywords or phrases were used in the review process. No attempt was made to record additional variables, such as gender, as that was considered beyond the scope of the study. A total of 92 reflective essays were reviewed during this study.

Results

Of the 92 student essays reviewed for this study, 6 (6.5%) did not clearly state when they made the choice to select civil engineering as their major, even though that was a plainly defined objective of the assignment. Those essays were removed from further consideration.

Of the remaining 86 student essays, 34 (39.5%) clearly reported that they selected the civil engineering major before arriving at West Point, and 52 (60.5%) stated that they selected the civil engineering major after arriving at West Point. Figure 1 shows the percentage of students selecting civil engineering both before and after arriving on campus.

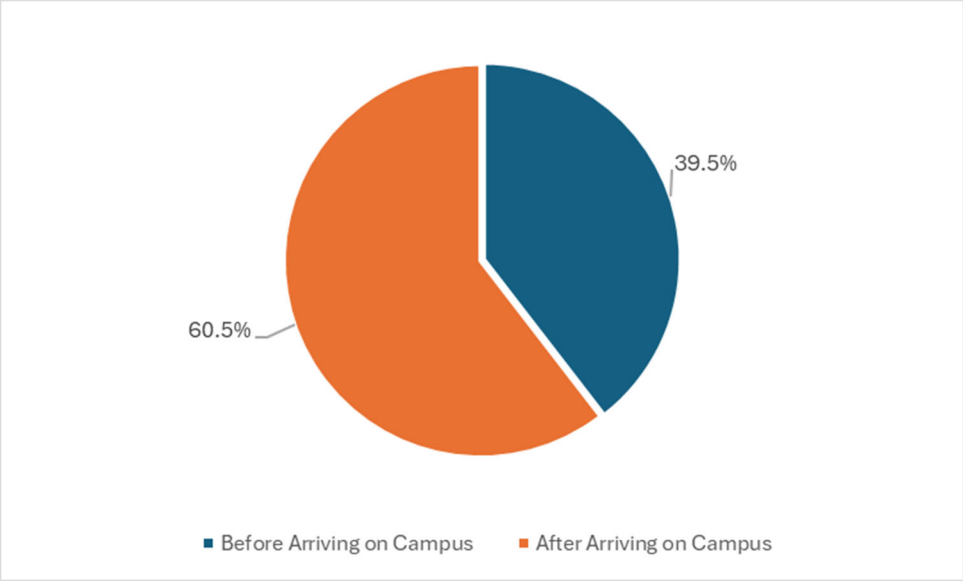

Figure 1. Percentage of Students Selecting Civil Engineering Before and After Arriving on Campus.

Of those 52 students who decided on their academic major after arriving at West Point, 18 (34.6%) reported making their decision after the majors fair, 16 (30.8%) reported making their decision after speaking with upperclassmen, 6 (11.5%) reported making their decision after speaking with a faculty member or similar mentor, and 3 (5.8%) reported that they switched into civil engineering after previously declaring a different academic major. The remaining 9 (17.3%) students simply stated that they selected their major after arriving at West Point, but they did not elaborate on specifically when their decision was made. Figure 2 presents the timing of when students selected the civil engineering major after arriving on campus.

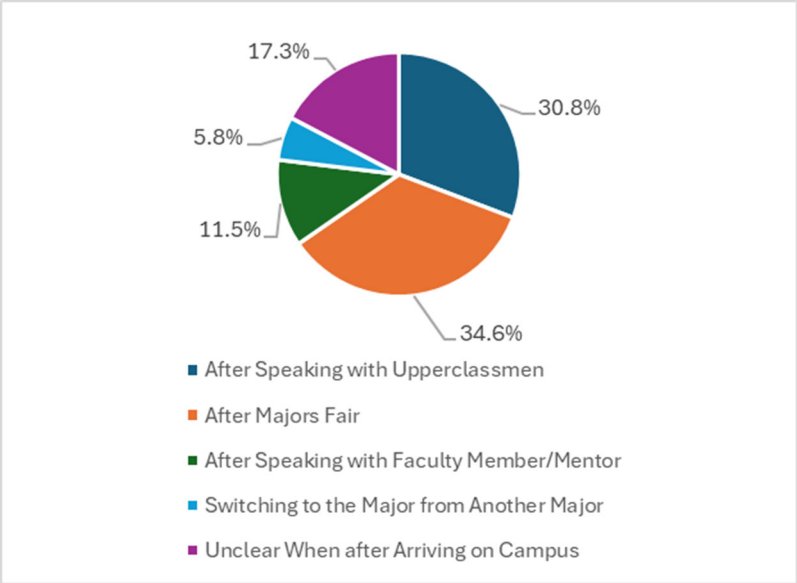

Figure 2. Timing of Declaring the Civil Engineering Major After Arriving on Campus.

Discussion

As illustrated in Figure 1, nearly 40% of the students in this study had already decided that they would major in civil engineering before they arrived on campus. Many of those students spoke about experiences they had during their pre-college years that helped them form their academic major decision. Many of those students spoke about experiences in high school, a handful spoke about middle school experiences, and one student even claimed to have made up his mind on the civil engineering major as early as elementary school. The student with the elementary school decision stated:

> "My initial exposure to civil engineering, and likely my main motivation for choosing it began in elementary school. My mother (who works for the NCDOT) would come to my school's career days and set up her North Carolina Department of Transportation booth, where she would bring asphalt and concrete samples and talk about what she did. I used to be proud to have her there, and I looked up to her for that."

Clearly, that student had a unique experience created by his mother's outreach activities. One of the students who selected the civil engineering major during middle school was fortunate to have an influential grandfather who was a civil engineer. That student stated:

> I began working on the family farm with my grandfather at an early age. It is very hard to become acquainted with farm work, there is so much to learn in a miniscule amount of time. Patiently my grandfather would teach how to work the farm, and most importantly how to think logically about situations. He was essentially teaching me the "Given, Find, and Solve" steps to real world issues. As I learned more, he allowed me to work independently. Solving issues on the farm gave me a sense of purpose. During the day we would work, and at night he

would explain concepts of what we built. I would act as if I knew what he was saying, but I would always get lost along the way. I wanted to understand, and I knew that Civil Engineering was my calling.

High school experiences were predominately the result of influential teachers, as captured in the following quotes:

> "My high school engineering instructor did more than just teach us a general understanding of engineering. He was able to educate us that becoming an engineer is more than just a job, becoming an engineer means we can change people's lives for the better whether the change is small or large."

> "It was then I decided to take a class named 'The Fundamentals of Engineering and Design" that my high school offered. I figured this class would give me all the necessary information to determine if Civil Engineering was truly my appropriate major. The first topic we covered in this class was the history, design, and intended use of a variety of bridges and structures. The Roman arch bridges of antiquity as well as the modern suspension bridges of today absolutely piqued my interest."

> "Lucky for me, I soon got an opportunity in high school to explore engineering in a joint school program called CT Center. With the CT center I was able to continue my pursuit of engineering with classes that allowed me to get a taste what a potential could be in the engineering field. The teachers in the classes were previously engineers. I was able to ask them questions about things that were taught outside the curriculum, such as how the on-site building looks like from a manager's point of view. One teacher was still a certified civil engineer and planned on returning to the field once her daughter graduated high school. This teacher was a great influence in inspiring me to join civil engineering, as she introduced me to such programs as Revit."

> "My interest in engineering grew even more when I was afforded the opportunity to attend the NJ Governor's School of Engineering and Technology going into senior year. There, while the work I did was not directly related to civil engineering, I conducted research and learned more about many different engineering disciplines, from robotics to aerospace to cyber. Despite all this exposure to a large swath of engineering fields, it was the lessons in energy, transportation, and materials that interested me the most."

> "Then, I took a civil engineering class in my junior year. This class introduced me to surveying, soil mechanics, and other civil engineering concepts while building on my prior experience with beam statics. These topics sparked my interest in civil engineering. Not only did the class make me think more about common infrastructure like roads, but I also saw the importance of math in designing some of this infrastructure. Although the class was challenging, I enjoyed learning. This class influenced me to eventually choose civil engineering as my major."

> "Then I entered a Technical Education class in my junior year of high school. This class covered topics from building mini rockets and making a chalice out of wood, to designing a bridge out of Balsa Wood. It was a class that required each student to get out of their comfort zone and think outside the box. My experience in Technical Education gave me my first deep dive into the how of engineering and after that class, I was propelled into wanting to become a civil engineer."

While fairly common, not all high school experiences occurred in the classroom. This student spoke about a neighbor who helped with the decision to major in civil engineering:

> "Mr. Bell, who was also my neighbor, agreed to guide me around his firm and onto several active projects for a week. I saw everything from water treatment to landfill construction. The landfill had particularly caught my attention with Caterpillar 740 dump trucks and D9 bulldozers navigating about an enormous pit that was soon to become the landfill itself. Caterpillar 395 excavators moved mountains of dirt from pits to piles. It was fascinating that the scale of such an operation could be put on paper like a playbook. That week was highly influential in my decision to become not just an engineer, but a civil engineer."

Numerous students stated that civil engineering had been an interest of theirs for a long period of time, with many of them referring to childhood experiences. For example, one respondent spoke about the influence of playtime with blocks as a child, followed by a technology class in middle school, and then a civil engineering and architecture class in high school. All of those were formative experiences, but that particular respondent then went on to say that the final decision to major in civil engineering did not occur until after they matriculated to college.

Slightly more than 60% of students (see Figure 1) selected the civil engineering major after arriving at West Point. The most common activity that resulted in declaring the civil engineering major was the majors fair. The civil engineering program has made a conscious decision, for several years, to assign dynamic and personable current civil engineering students to the majors fair room for freshmen to interact with. This decision appears to have been impactful based on the following quotes:

> "But the most influential factor was the majors fair. I felt that I had a decent amount of information and experience about engineering in general when I showed up to the majors fair, however, I couldn't really identify the difference between mechanical and civil engineering. After wandering through both rooms and reading the brochures, I was already leaning towards civil engineering, but it wasn't until one of the other civil engineering students approached me and answered all my questions. They made me feel welcome and gave me confidence to pursue something new and interesting."

> "The majors fair influenced me to finalize my choice of civil engineering as a major. I checked out other STEM fields as I was already here, but I was very impressed and excited about the civil engineering program and its opportunities.

Those already in the major seemed smart and charismatic and the faculty I met were all passionate and intelligent."

For those students who remained unconvinced after participating in the majors fair, it appears that conversations with upperclassmen (commonly on a sports team or in a shared living area) and conversations with civil engineering faculty members, as well as mentors, were a common impetus for declaring the civil engineering major.

Conclusions

Clearly, not all academic institutions operate on an academic major declaration timeline similar to West Point. The authors acknowledge that many academic institutions require their students to declare (and in some cases be accepted to) an academic major at the time of matriculation. Thus, the findings of this study may be of particular interest to civil engineering programs where students select their academic major after arriving on campus. Future studies could be dedicated to investigating how the findings of this study compare to academic institutions with different timelines for declaring one's academic major.

To address the study's research questions, the majority (60.5%) of students in the civil engineering program at West Point did not select their major until required to do so during the second semester of their freshman year. The remaining group of students (39.5%) selected civil engineering at various points of time between their elementary school years and high school years.

Many civil engineering programs engage in STEM outreach activities for pre-college students. In numerous cases those activities involve teaming with industry representatives. Those activities are critically important to promoting the profession of civil engineering and getting students interested in pursuing civil engineering education. However, such efforts are difficult to link between pre-college student engagement and enrollment in specific civil engineering programs.

Civil engineering programs within academic institutions where students do not declare their major upon matriculation should carefully consider the nature and timing of recruiting activities among the on-campus population. Given the large percentage of students who arrive on campus without a definitive academic major, programs have an opportunity to bolster their enrollment numbers by proactively and strategically recruiting those students.

As noted previously, a substantial amount of literature exists that discusses the "why" students select a particular academic major, and some of that literature is specific to engineering. There is a definitive lack of literature related to "when" students select their academic major. Thus, this study helps to address that void in the existing literature.

References

[1] DeFazio, P. A., *H.R.3684 Infrastructure Investment and Jobs Act*, 117th Congress, 2022, https://www.congress.gov/bill/117th-congress/house-bill/3684, accessed 26 September 2024.

[2] Longley, K., *ASCE Celebrates Two-Year Anniversary of the Bipartisan Infrastructure Law*, American Society of Civil Engineers, 2023, https://infrastructurereportcard.org/asce-celebrates-

two-year-anniversary-of-the-bipartisan-infrastructure-law/#:~:text=It%20is%20estimated%20that%20the%20IIJA%20has%20created%20an%20additional, accessed 26 September 2024.

[3] U.S. Bureau of Labor Statistics, *Occupational Outlook Handbook – Civil Engineers*, 2024, https://www.bls.gov/ooh/architecture-and-engineering/civil-engineers.htm#:~:text=Employment%20of%20civil%20engineers%20is%20projected%20to%20grow,projected%20each%20year%2C%20on%20average%2C%20over%20the%20decade, accessed 26 September 2024.

[4] National Assessment of Education Progress, The Nation's Report Card, 2022, https://www.nationsreportcard.gov/, accessed 26 September 2024.

[5] Graves, W., Matarazzo, T. J., Barry, B. E., Bristow, E., and Evans, M., *Why Students Select the Civil Engineering Major*, American Society for Engineering Education Annual Conference, 2023.

[6] Matusovich, H. M., Streveler, R. A., and Miller, R. L., *Why do Students Choose Engineering? A Qualitative Longitudinal Investigation of Students' Motivational Values*, Journal of Engineering Education, 99-4, 2010.

[7] Ngambeki, I., Dalrymple, O., and Evangelou, D., *Decision Making in First Year Engineering: Exploring How Students Decide About Future Studies and Career Pathways*, Purdue University, School of Engineering Education Graduate Student Series, 2009.

[8] Painter, J. K., Snyder, K. E., and Ralston, P. A., *Why Engineering?: Students' Reasons for Choosing and Engineering Major*, American Society for Engineering Education Annual Conference, 2017.

[9] Meyers, K. L., Bucks, G. W., Haper, K. A., and Goodrich, V. E., *Multi-Institutional Evaluation of Engineering Discipline Selection,* American Society for Engineering Education Annual Conference, 2015.

[10] Mohammadi-Aragh, M. J., Warnock, J., Barton, A., Sullivan, R. W., Elmore, B. B., and Moorhead, J. N., *Hybrid Engineering Matriculation Model to Promote Informed Engineering Major Selection Decisions*, American Society for Engineering Education Annual Conference, 2015.

[11] VanDeGrift, T. and Liao, S., *Helping First-Year Engineering Students Select a Major*, American Society for Engineering Education Annual Conference, 2017.

[12] Elmore, M., Gieskes, K. E., and Alfarano, N., *Factors in the Selection of a Major by First-Year Engineering Students*, American Society for Engineering Education Annual Conference, 2022.

[13] Elmore, M. and Gieskes, K. E., *First-Year Engineering Students and Factors in Their Selection of a Major*, American Society for Engineering Education Annual Conference, 2021.

[14] Zahorian, S., Elmore, M., and Temkin, K. J., *Factors that Influence Engineering Freshman to Choose their Engineering Major,* American Society for Engineering Education Annual Conference, 2013.

[15] Main, J. B., Griffith, A. L., Xu, X., and Dukes, A. M., *Choosing an Engineering Major: A Conceptual Model of Student Pathways into Engineering*, Journal of Engineering Education, 111-1, 2022.

[16] Cruz, J. and Kellam, N., *Beginning and Engineer's Journey: A Narrative Examination of How, When, and Why Students Choose the Engineering Major*, Journal of Engineering Education, 107-4, 2018.

[17] Patterson, R. W., Pope, N. G., and Feudo, A., *Timing Matters: Evidence from College Major Decisions*, The Journal of Human Resources, 58 (4), 2023.