Engineering Major Selection: Impacting Factors and Facilitating Classroom Strategies

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Abstract

In this complete research paper, the factors impacting engineering/computer science major selection were investigated in a first-year course. Major selection is related to the recruitment of students into the engineering/computer science pipeline and is a decision that impacts individuals throughout their lifetime. Surveys were administered at the beginning and end of the semester in a first-year introduction to engineering course. Students indicated the most important factor influencing their major selection was job opportunities after graduation. Other important factors included personal interest and salary levels. There were no statistically significant differences in ranked factors by gender, but first-generation college students ranked personal interest and having role models in family/friends in the same major lower than non-first-generation college students. There were also statistical differences between majors, with computer science students ranking salary levels and job opportunities after graduation higher than civil, electrical, and mechanical engineering majors. Lastly, students' certainty in their choice of major significantly increased from the beginning to the end of the semester. Based on the survey results, a module was added to the course to familiarize students further with job opportunities associated with various engineering/computer science majors. This work provides context for recruiting students into engineering and computer science majors and for integrating information on career opportunities into first-year courses.

Introduction

The major students select before or during the first year of their studies at the university impacts them significantly for the rest of their careers [1], [2]. These impacts include job satisfaction, socioeconomic status, and career success. Therefore, investigating the factors that shape this decision is crucial. There have been several studies regarding engineering/computer science major selection, and how it is impacted by various contributing factors. Most of these studies have been done in a first-year introductory engineering course using student surveys as the main data collection method [3], [4], [5], [6], [7], [8], [9]. Rodriguez et al. identified the top three impacting factors as self-led exploration, family and friends, and department presentations [3]. Zahorian et al. found that the top three influencing factors were personal academic interests, potential for societal contributions, and job prospects [4]. Carnasciali et al. reported personal academic interests, job security, and occupational growth as the top impacting factors [8]. Noonan et. al. listed self-led exploration and family members as the most influential [9]. In this work, impacting factors not investigated in the previous works, such as salary levels after graduation, work/life balance, and the perceived level of difficulty of the majors were included in the surveys. In addition, the results of the survey at the beginning of the semester were used as a

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guideline to add relevant content to the course aiming at helping students make more informed decisions.

This work investigated two research questions: 1) What are the most important factors influencing engineering/computer science major selection and how is this impacted by the first-year experience? and 2) How do demographics relate to students' major selection? Student surveys were the main tool for data collection. Based on the survey results, a module was added to the first-year Introduction to Engineering course where students researched and presented on possible job opportunities for engineering/computer science majors.

Methods

A student survey was created and administered to 126 students in five sections of a first-year course titled Introduction to Engineering (EGR 110). Students are admitted to the school of engineering in a chosen major (civil engineering, computer science, electrical engineering, mechanical engineering) or as undeclared within engineering. The requirements for admissions for all engineering/computer sciences majors are identical. The course introduces students to the engineering/computer science majors offered at this university through hands-on labs and culminates with a team design project in which students design and build a tabletop wind turbine. The survey questions analyzed in this work are 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) questions. The survey was administered twice, during the first week of the semester (pre-survey), and again during the last week (post-survey) (Table 1). In addition, students' demographics data was self-reported in the survey for gender and first-generation college student status. Note that for the question regarding the importance of impacting factors, each factor was rated 1–5 (not at all important to extremely important), independent of other factors. In other words, students did not rank each factor in comparison to others but rated them separately.

Surveys were filled out anonymously, with a random number assigned to each student to allow for within-subject comparisons. The study was approved by the university's IRB and consent was obtained from all participants.

Table 1. The questions analyzed in this study from the student survey administered at the beginning of the semester (pre-survey) and at the end of the semester (post-survey).

Pre/Post	Question	Answers to choose, rank, or rate
Pre, Post	What is your current engineering major?	Civil Engineering Electrical Engineering Mechanical Engineering Computer Science Not Engineering or Computer Science Undeclared
Pre, Post	If undeclared, which engineering major are you thinking about choosing?	Civil Engineering Electrical Engineering Mechanical Engineering Computer Science Not Engineering or Computer Science

Pre, Post	How certain are you about your major selection? (1: Not at all certain – 5: Extremely certain)	Not at all certain Slightly certain Moderately certain Very certain Extremely certain
Pre, Post	How important was each factor below in choosing the engineering (electrical/mechanical/civil/computer science) or non-engineering major you are currently in (or will be in, if you are currently undeclared)? (1: Not at all important – 5: Extremely important)	A) Personal interest B) Abilities/talents C) Job opportunities after graduation D) Salary levels E) Opportunity to serve the society F) Desired work/life balance G) Role models in family/friends in the same major H) What my family want me to study I) What I have been told to study (by teachers, etc.) J) How difficult I think the major will be
Pre, Post	Rank the engineering major based on how difficult you think the subject matters are to learn (1: Easiest – 4: Most difficult).	Civil Engineering Electrical Engineering Mechanical Engineering Computer Science
Post	After completing the EGR110 course, I now have a better understanding of different engineering disciplines and computer science.	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree
Post	After completing the EGR110 course, I now have a better understanding of job prospects for different engineering disciplines and computer science.	Strongly agree Agree Neither agree nor disagree Disagree Strongly disagree

Statistical Analysis

Before analysis, data from students who did not complete both the pre-survey and post-survey data were removed. A Wilcoxon signed-rank test was used to determine if there were differences in pre- to post-survey data for major certainty, factor importance, and rank of difficulty for majors. Additionally, to compare differences in factor importance at the pre-survey in student demographics (male/non-male, first generation/non-first generation, major chosen at the start of the semester), Mann Whitney U or Kruskal-Wallis tests were conducted. The analysis was conducted in JMP Pro 16.2.0 (JMP Statistical Discovery LLC, Cary, NC), with significance set at $p<0.05$.

Results and Discussion

Factors Influencing Major Selection

While 122 students filled out the pre-survey, and 107 students filled out the post-survey, only 99 students completed both the pre- and post-survey with no missing data. The top three factors impacting major decisions at the beginning of the semester for all students were job opportunities after graduation, personal interest, and salary levels (Table 2). All three of these factors had an average importance level greater than 4 on the provided scale from 1 (not at all important) to 5 (extremely important). While the influential impacting factors found in the literature vary, job prospects and personal interest are most identified as top factors by other studies [4], [8], which agrees with our results. The salary level, however, has not been investigated extensively by other groups.

The top three impacting factors remained the same at the end of the semester, suggesting the course had little impact on the top factors that affect students' major selection. Other factors that ranked highly included the opportunity to serve society (pre-survey average = 3.8 ± 1.0), students' perceived abilities/talents (pre-survey average = 3.6 ± 0.8), and desired work/life balance (pre-survey average = 3.6 ± 1.1) (Table 2). Contrary to another study which found almost 20% of first-year engineers identified family influences as a reason for choosing engineering, in the current study both family influence and being told by others to study engineering ranked lowest (pre-survey average < 2; Table 2) [10]. Other work has also identified the effect of family and friends as influential [3], [9]. This may indicate a shift in students' priorities regarding the influence of family and friends in recent years, as these studies occurred more than 5 years ago.

Among all the factors, the importance level of two changed significantly from pre-survey to post-survey: (H) "What my family wants me to study" increased from 1.9 ± 1 (mean ± standard deviation) to 2.2 ± 1.1 ($p = 0.027$), and (I) "What I have been told to study (by teachers, etc.)" increased from 1.7 ± 0.9 to 2.3 ± 1.1 ($p < 0.001$). The reason for the increase in the impact of family is unclear. The increase in the importance of what teachers suggest may be due to interactions students had with instructors during their first semester. During the semester, all students were required to meet with their course instructor one-on-one to discuss their first semester, including their impressions of the university, the school of engineering, and the major. The university is small, with average class sizes under 30 for first-year students. These small class sizes allow for increased feedback and higher faculty interaction which can result in higher levels of satisfaction for students, potentially causing an increase in the importance of teachers [11].

Table 2. The average importance level of impacting factors pre-survey and post-survey. Students rated each factor from 1 (not at all important) to 5 (extremely important). Mean ± standard deviation reported. * indicates significance between pre- and post-survey results, $p<0.05$. Factors with a level of importance > 4 are shaded in grey.

Impacting Factor	Pre	Post
A) Personal interest	4.1 ± 0.7	4.2 ± 0.8
B) Abilities/talents	3.6 ± 0.8	3.8 ± 0.9
C) Job opportunities after graduation	4.3 ± 0.8	4.2 ± 0.8
D) Salary levels	4.0 ± 0.9	4.0 ± 0.9
E) Opportunity to serve the society	3.8 ± 1.0	3.5 ± 1.1
F) Desired work/life balance	3.6 ± 1.1	3.7 ± 0.9
G) Role models in family/friends in the same major	2.5 ± 1.3	2.6 ± 1.4
H) What my family wants me to study	1.9 ± 1.0	2.2 ± 1.1*
I) What I have been told to study (by teachers, etc.)	1.7 ± 0.9	2.3 ± 1.1*
J) How difficult I think the major will be	2.6 ± 1.1	2.6 ± 1.1

Students' certainty about their declared major significantly increased from 3.6 ± 0.9 to 3.9 ± 1.0 ($p = 0.006$), with 1 being not at all certain and 5 being extremely certain. This demonstrates that taking the Introduction to Engineering course may have helped students become more confident about their selected major. This was likely achieved through hands-on exposure to each major, the knowledge they acquired about majors throughout the course, and interactions with faculty.

As part of the survey, students ranked the four majors of electrical engineering, mechanical engineering, civil engineering, and computer science, based on their perceived level of difficulty (1: Easiest – 4: Most difficult). The goal of this question was to discern whether students' perceived level of difficulty of each engineering/computer science major impacts their major selection. According to the pre-survey, the majority (54%) of students ranked their major as 1 or 2 (easiest or easy), while the remaining 46% ranked their major as 3 or 4 (difficult or most difficult). This indicates a potential relationship between students' perceived difficulty level and their major selection.

In the post-survey, 51% of students ranked their major as 1 or 2 (easiest or easy), while the remaining 49% ranked their major as 3 or 4 (difficult or most difficult). The perceived difficulty level did not change significantly from pre-survey to post-survey for civil engineering, mechanical engineering, and computer science. However, there was a significant increase for electrical engineering from 2.9 ± 0.9 to 3.2 ± 0.9 ($p = 0.006$), meaning on average, all students ranked electrical engineering as a more difficult major after the course. We hypothesize this is due to the integration of circuits within the course; students were tasked with wiring an Arduino as part of their final wind turbine project. The students appeared to struggle with this content more so than other components of the course and may have connected it to majoring in electrical engineering.

Impact of Demographics on Initial Major Selection

Most students in the course were mechanical engineers (33.3%), followed by computer scientists (29.3%), then civil engineers (25.3%), and electrical engineers (8.1%) (Figure 1). There was a minimal shifting of majors from the pre- and post-survey, with one student joining mechanical engineering, two students leaving computer science, and an additional two students declaring a non-engineering major.

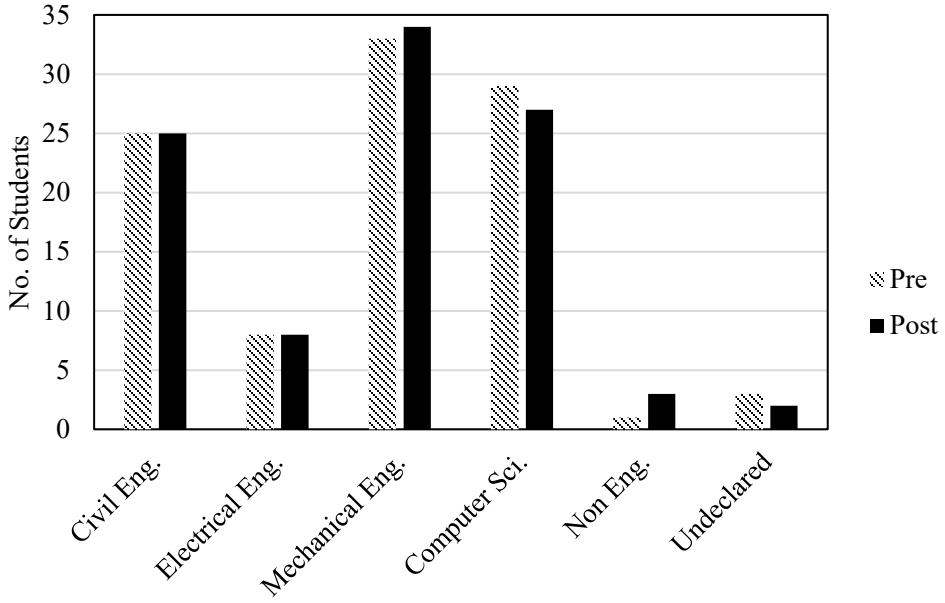

Figure 1. Number of students in engineering/computer science and non-engineering majors, as well as undeclared, according to pre-survey and post-survey.

Among the students who filled out both surveys, the gender distribution was as follows: 71 male, 21 female, and 3 nonbinary. Four students chose not to provide a gender. Electrical engineering had the highest percentage of male students, while civil engineering had the highest percentage of female students (Figure 2).

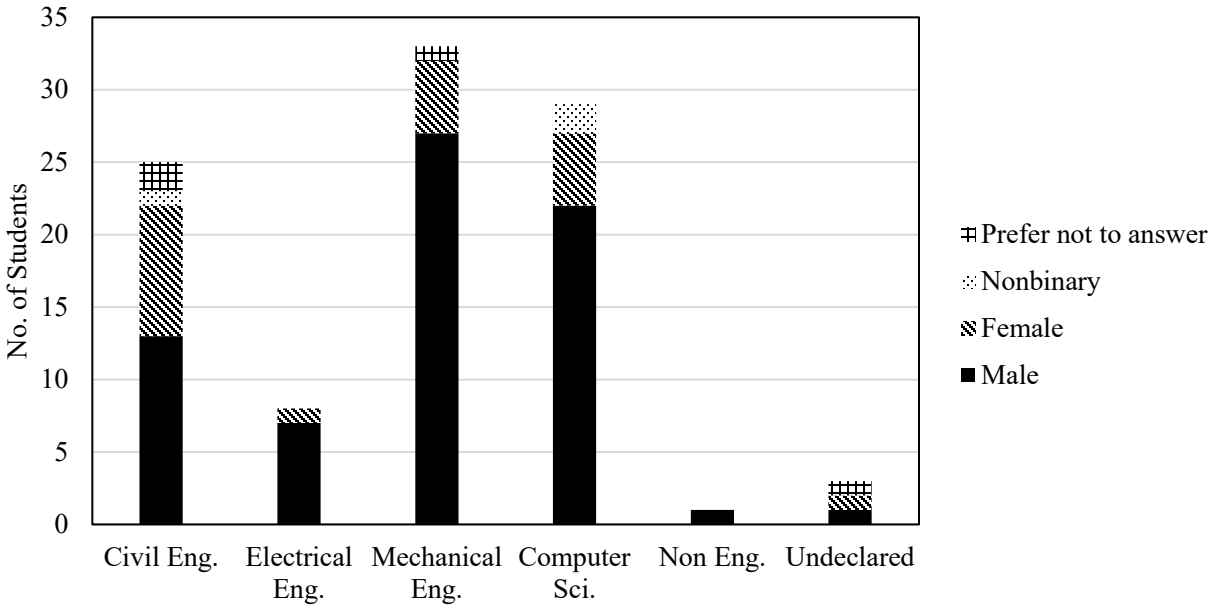

Figure 2. The number of male, female, nonbinary students, and those who preferred not to answer the gender question, in engineering/computer science and non-engineering majors, as well as undeclared, according to post-survey.

There was no significant difference for any impacting factor when comparing across gender (male/non-male) at the start of the semester. The level of certainty in choosing a major was also not significantly different across genders.

Two impacting factors, personal interest ($p = 0.025$) and role models in family/friends in the same major ($p = 0.049$), were significantly different at the start of the semester for first-generation college student (first-gen) status (Table 3). Previous studies have identified the lack of engineering role models as a challenge for first-gen students [12], [13], [14]. This status prevents students from learning about engineering until later in their secondary education [12]. It is also evident from previous research that non-first-gen students benefitted from engineering-specific actions and information, while first-gen students used their familial relationship for more general emotional support during their major selection [13]. There seems to be a lack of support in math and science in the family for first-gen students, as they have identified these topics as “not a family interest” [14]. This may contribute to the lower rating of personal interest compared to non-first-gen students.

Table 3. The average importance level of impacting factors pre-survey for first-gen students and non-first-gen students. Students rated each factor from 1 (not at all important) to 5 (extremely important). Mean ± standard deviation reported. * indicates significance between groups, p<0.05. Factors with a level of importance > 4 are shaded in grey.

Impacting Factor	First Gen (n = 29)	Non First Gen (n = 69)
A) Personal interest	3.9 ± 0.7	4.2 ± 0.7*
B) Abilities/talents	3.5 ± 0.7	3.7 ± 0.8
C) Job opportunities after graduation	4.1 ± 0.9	4.3 ± 0.8
D) Salary levels	4.0 ± 0.9	4.0 ± 0.9
E) Opportunity to serve the society	3.5 ± 1.0	3.9 ± 0.9
F) Desired work/life balance	3.6 ± 1.0	3.5 ± 1.1
G) Role models in family/friends in the same major	2.1 ± 1.2	2.7 ± 1.3*
H) What my family wants me to study	1.9 ± 1.1	2.0 ± 1.0
I) What I have been told to study (by teachers, etc.)	1.9 ± 1.0	1.7 ± 0.8
J) How difficult I think the major will be	2.6 ± 1.0	2.6 ± 1.1

Impacting factors were compared at the start of the semester based on chosen major (Table 4). Computer science students rated job opportunities after graduation significantly higher than civil engineering and mechanical engineering students ($p = 0.009$). Computer science students also rated salary levels as an impacting factor when choosing their major, higher than all other majors ($p < 0.001$). Although not statistically significant, civil engineers ranked the opportunity to serve society higher than all other majors (4.1 ± 0.8). Another study found civil engineering, along with bioengineering and chemical engineering, two majors not offered at the study's institution, ranked potential for societal contributions higher than other majors [15].

Table 4. The average importance level of impacting factors pre-survey by major. Civil engineering (CE), electrical engineering (EE), mechanical engineering (ME), and computer science (CS). Students rated each factor from 1 (not at all important) to 5 (extremely important). Mean ± standard deviation reported. * indicates significance between groups, p<0.05. Factors with a level of importance > 4 are shaded in grey.

Impacting Factor	CE (n = 25)	EE (n = 8)	ME (n = 33)	CS (n = 29)
A) Personal interest	4.1 ± 0.7	4.3 ± 0.5	4.2 ± 0.7	3.9 ± 0.8
B) Abilities/talents	3.8 ± 0.7	3.4 ± 0.7	3.5 ± 0.8	3.6 ± 0.9
C) Job opportunities after graduation	4.2 ± 0.7	4.0 ± 0.5	4.1 ± 1.0	4.6 ± 0.7*
D) Salary levels	3.9 ± 1.0	3.5 ± 0.5	3.7 ± 1.0	4.6 ± 0.6*
E) Opportunity to serve the society	4.1 ± 0.8	3.8 ± 0.7	3.7 ± 1.0	3.4 ± 1.0
F) Desired work/life balance	3.6 ± 1.0	3.0 ± 1.1	3.5 ± 1.0	3.6 ± 1.2
G) Role models in family/friends in the same major	2.5 ± 1.3	2.4 ± 1.1	2.3 ± 1.2	2.6 ± 1.4
H) What my family wants me to study	2.3 ± 1.1	1.8 ± 1.2	1.6 ± 0.9	2.1 ± 1.0
I) What I have been told to study (by teachers, etc.)	2.2 ± 1.1	1.6 ± 0.7	1.6 ± 0.7	1.6 ± 0.8
J) How difficult I think the major will be	2.7 ± 0.9	2.5 ± 1.4	2.3 ± 1.1	2.7 ± 1.1

Impact of Introduction to Engineering Course

Students were asked at the end of the semester (post-survey) if the Introduction to Engineering course has improved their understanding of different engineering/computer science majors and corresponding job prospects. Students felt they had a better understanding of different engineering disciplines and computer science (3.77 ± 1.11, mean ± standard deviation), and felt they had a better understanding of job prospects for different engineering disciplines and computer science (3.85 ± 1.07). The percentage of students for each response (strongly disagree to strongly agree) was calculated to demonstrate the distribution of responses (Figure 3). Survey results indicate that 75% of students agreed or strongly agreed the course helped them get a better understanding of engineering disciplines, and 80% of students agreed or strongly agreed the course helped them understand the job prospects for each discipline better.

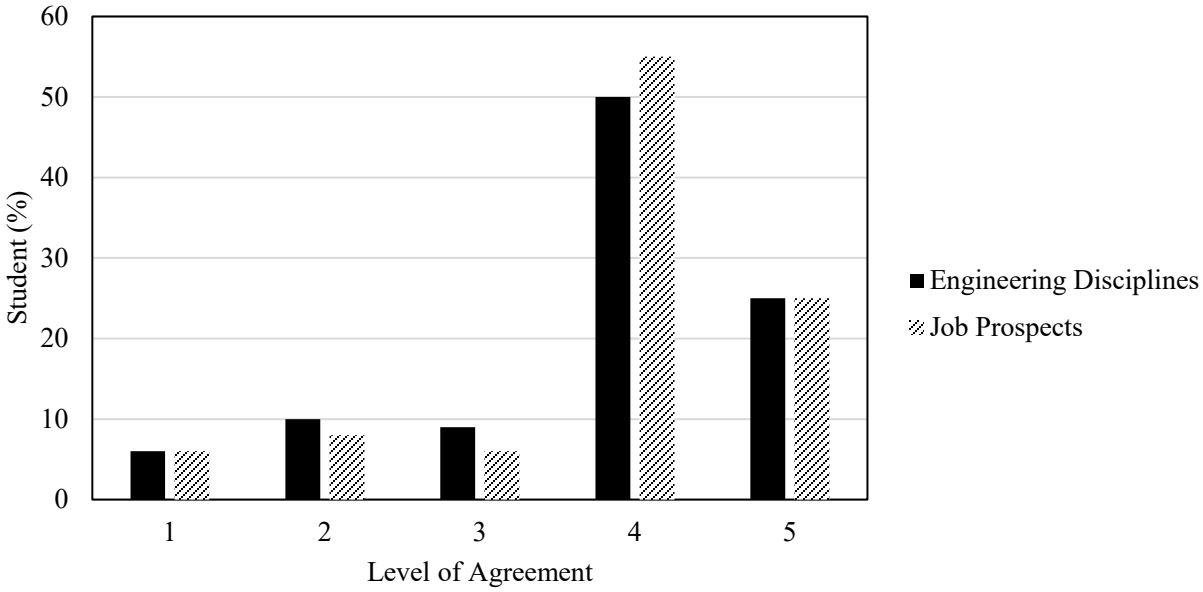

Figure 3. Percentage of students in each agreement level at the post-survey when asked if they gained a better understanding of the engineering and computer science disciplines (black) and job opportunities (patterned) after completing the Introduction to Engineering course. Students rated each question from 1 (strongly disagree) to 5 (strongly agree).

Improvements to Introduction to Engineering Course

Since two out of three factors were related to jobs after graduation, the instructors found it critical to expand students' understanding of job opportunities for engineering/computer science majors. Therefore, a new module was added to the Introduction to Engineering course. In the module, students were paired in teams of two, and a list of possible engineering/computer science job titles was provided. Each team selected a job title, researched the job title, and presented the results to the class. A list of possible questions to guide the research was provided to students, with some examples listed below:

- What does a day in the life of this type of engineer/computer scientist look like?

- What are typical industries or sectors where this role is found?
- What degrees (engineering/computer science majors) may have this job title?
- What companies hire this type of engineer/computer scientist?
- What career advancement opportunities exist and what are potential salary ranges?

This module provided students exposure to a wide range of engineering/computer science jobs, what they entail, and salary levels. The hope was this would allow students to make more informed decisions about their engineering/computer science major.

Based on the survey results, some changes to the Introduction to Engineering course will be implemented to guide students' major selection better. In addition to student presentations on job opportunities, it will be beneficial to invite guest lecturers from industry for each engineering/computer science major to talk about their direct experience. Also, since the perceived level of difficulty for Electrical Engineering increased significantly after taking this course, the complexity level of the lab designed for this major will be reduced.

Conclusion

This work investigated how students select their engineering or computer science major by examining factors affecting their decision. Based on the survey results, the top three factors impacting major selection were job opportunities after graduation, personal interest, and salary levels. Examining demographics, gender did not have a significant effect on impacting factors, but first-generation college student status did, with first-generation students ranking personal interest and role models significantly lower than non-first-generation students. There were differences in impacting factors between majors, with computer science students rating job opportunities and salary higher than all other majors. Lastly, how certain students were in choosing their major increased significantly from the beginning to the end of the semester, suggesting that the first-year engineering course had a positive effect on students' confidence about their major selection. This work could provide a framework for best recruiting students into engineering majors as well as provide guidance in updating first-year curricula with information relevant to students' motivation for studying engineering.

References

[1] K. Leppel, "The impact of major on college persistence among freshmen," *High Educ (Dordr)*, vol. 41, pp. 327–342, 2001.

[2] K. M. Galotti, "Making a 'Major' Real-Life Decision: College Students Choosing an Academic Major," *J Educ Psychol*, vol. 91, no. 2, pp. 379–387, 1999.

[3] H. Rodriguez-Simmonds, J. Ortega-Alvarez, S. Atiq, and S. Hoffmann, "Identifying sources of information that students use in deciding which engi-neering major to pursue Identifying sources of information that first year engineering students use in deciding which engineering major to pursue," in *122nd ASEE Annual Conference and Exposition*, 2015, pp. 26.877.1-26.877.16.

[4] S. Zahorian and S. A. Zahorian, "Factors that Influence Engineering Freshman to Choose Their Engineering Major Factors that Influence Engineering Freshman in Choosing Their Major," in *120th ASEE Annual Conference and Exposition*, 2013, pp. 23.589.1-23.589.13.

[5] B. M. Argrow and B. Louie, "Introduction to Engineering: Preparing First-Year Students for an Informed Major Choice," in *ASEE Annual Conferenc and Exposition*, 2012, pp. 25851.1-25851.20.

[6] J. B. Main, K. J. Mumford, and M. W. Ohland, "Examining the Influence of Engineering Students' Course Grades on Major Choice and Major Switching Behavior*," *International Journal ofEngineering Education*, vol. 31, no. 6(A), pp. 1468–1475, 2015.

[7] A. Theiss, "Engineering Major Selection: An Examination of Initial Choice and Switch-ing Throughout the First Year," in *ASEE 123rd Annual Conference and Exposition*, 2016.

[8] M.-I. Carnasciali, A. E. Thompson, and T. J. Thomas, "Factors influencing students' choice of engineering major," in *120th ASEE Annual Conference and Exposition*, 2013, pp. 23.587.1-23.587.36.

[9] J. S. Noonan, W. C. Oakes, and P. K. Imbrie, "First-year engineering students' choice of major: When it is made and what influences it," in *American Society for Engineering Education*, 2006.

[10] J. K. Painter, K. E. Snyder, and P. A. Ralston, "Why Engineering?: Students' reasons for choosing an engineering major. Why Engineering? Students' Reasons for Choosing an Engineering Major," in *ASEE Annual Conference and Exhibition*, 2017.

[11] J. Cuseo, "The empirical case against large class size: Adverse effects on the teaching, learning, and retention of first-year students," *J Fac Dev*, vol. 21, no. 1, pp. 5–21, 2007, [Online]. Available: https://www.researchgate.net/publication/228378064

[12] Michael J. Fernandez, Julie Martin Trenor, Katherine S. Zerda, and Cassandra Cortes3, "First Generation College Students in Engineering: A Qualitative Investigation of Barriers to Academic Plans," in *38th ASEE/IEEE Frontiers in Education Conference*, IEEE, 2008.

[13] J. P. Martin, S. K. Stefl, L. W. Cain, and A. L. Pfirman, “Understanding first-generation undergraduate engineering students’ entry and persistence through social capital theory,” *Int J STEM Educ*, vol. 7, no. 1, Dec. 2020, doi: 10.1186/s40594-020-00237-0.

[14] Dina Verdín and Allison Godwin, “First in the Family: A Comparison of First-Generation and Non-First-Generation Engineering College Students,” in *Frontiers in Education 2015 : launching a new vision in engineering education*, 2015.

[15] J. C. McNeil, P. A. Miller, and J. J. Saleem, “Influential Factors on Selecting an Engineering Major in a First-Year Course,” *Journal of Professional Issues in Engineering Education and Practice*, vol. 145, no. 2, Apr. 2019, doi: 10.1061/(ASCE)EI.1943-5541.0000405.