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# Gender Diversity in Undergraduate Engineering: Understanding the Major Selection Process

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# Gender Diversity in Undergraduate Engineering: Understanding the Major Selection Process

Diversity is a discussion on perhaps every college campus in the United States. Studies (IMF, 2018) point to the value of having students from varied populations, based on race, religion, national origin, and gender. Likewise, literature suggests that students also have more robust and meaningful educational experiences when surrounded by diverse faculty and staff (Bauer 2018, Bier 2016, Tinto 1993). Despite the efforts to diversify institutional makeup and culture, some areas of academia still struggle to have student and faculty bodies composed of populations that mirror the general population. The lack of women in STEM fields has been widely noted in literature, and sustained efforts to systematically address gender disparity have led to dramatic increases in female participation in health-related STEM fields. Meanwhile, women remain largely underrepresented in engineering. (Fry, 2021) This trend is one of the motivations for this study.

It is well documented in the literature that men and women enroll in college at different rates, graduate at different rates, select different majors, and have different experiences on college campuses. Avolio, Chávez, and Vilchez-Román (2020) explain the factors that contribute to the lack of representation of women in the science fields. Their research revealed that science curriculum and pedagogy, academic performance, and opinion about the individual's capability in science are among the educational factors that contribute to discrepancies between male and female student representation in science. Ceci and Williams (2011) argue that though many scholars who have investigated underrepresentation of women in science, technology, engineering, and mathematics (STEM) fields suggest the existence of discrimination, the research simultaneously fails to recognize the existence of other current issues at play in the underrepresentation.

Ismail, Zulkifli, and Hamzah (2017) analyze the evidence that suggests that despite women's efforts to be successful and recognized in engineering, they still lack representation in the engineering profession. Moreover, the authors acknowledge that several factors such as misconceptions about engineering, lack of opportunities, and other factors serve as barriers preventing women from choosing a career path that is still considered a non-traditional career for females. The authors identify specific perceptions of women in engineering that create barriers such as the fact that women are affected psychologically (e.g. thinking they cannot succeed, industry image, expectations for women), family barriers, and lack of enough mentors or role models.

In order to increase the participation of women in the field of engineering, more women must choose to study engineering as their college major. The literature shows two main factors that affect students' selection of college major: academic aptitude and personal expectations. Some studies have found a difference in these variables based on gender. Malgwi, Howe, and Burnaby (2005) found that male students choose majors based on potential career options, while female students choose majors based on academic ability.

Malgwi, Howe, and Burnaby (2005) examined variables important to both the initial selection of a particular major and any factors, positive or negative, related to a subsequent change in major. Results from the study determined student interest in the subject was the leading factor for entering freshmen, regardless of gender. For females, the second most important factor was aptitude in the subject. However, males were significantly more influenced by the potential for career advancement and job opportunities, along with the level of expected compensation in the field. If students chose to change majors, they appeared to be driven to make a change in the field of study by positive factors about the new major, rather than negative factors related to the old major.

The literature on college major selection is thus replete with mechanisms that can account for gender differences in the likelihood of selecting a science-related major. Xie and Shauman's (2003) offer a life course perspective that allows ''the significant events and transitions in an individual's life [to be] age-dependent, interrelated, and contingent on (but not determined by) earlier experiences and societal forces'' (2003:12). This research found gender differences in intended college major or in college major selection among the college-bound high school students could not be attributed to gender differences in high school coursework, tested performance, future work–family orientation, or self-assessed competence in math. Based on a series of empirical models, the authors determined that "none of the variables examined has significant power in explaining the sex differences in the likelihood that students who enroll in college choose to pursue a science or engineering major'' (Xie and Shauman, 2003:91). The authors concluded that for all the attention focused on performance on standardized tests, coursework, or expected work–family orientation, gender differences in these variables offer remarkably little leverage to explain gender differences in STEM major selection.

Ceci, Williams and Barnett (2009) claim that there are gender differences in occupational preferences that occur between objects and people. Women are more likely to pursue people-oriented or organic fields, whereas men with similar mathematics and science ability tend to pursue object-oriented fields. The research supports a common belief that gender differences in occupational preferences reflect women's deeply rooted preferences

for caring or nurturing, that, when coupled with beliefs about the incompatibility of science fields with those priorities, make women less likely to pursue STEM occupations.

Morgan, Gelbgiser, and Weeden (2013) analyzed gender differences in college major selection by conducting a longitudinal study over four years. The authors focused on the paths taken by students through college that lead to science, engineering, or medical fields. The data showed that gender differences in college major selection remained substantial, even for a data group in which rates of enrollment in college education were higher for young women than for young men. The results demonstrated that neither gender differences in work–family goals nor in academic preparation explain a substantial portion of these differences in major selection.

However, Morgan, Gelbgiser, and Weeden's (2013) research identified the occupational plans of high school seniors as strong predictors of initial college major selection. The authors also found the association between occupational plans and college major selection is not attributable to work–family orientation or academic preparation. The research pointed to the importance of occupational plans formed in adolescence for understanding the gender differences in college major and for policies intended to create a workforce that is representative and rewarding for both genders in all areas of STEM.

Design of the study

To design the research survey, four previous studies and associated surveys were consulted: Kuechler & Simkin (2009); Arcidiacono & Kang (2012); Culpepper (2006); and Malgwi, Howe & Burnaby (2005). Our study targets undergraduate students to determine:

(1) Do male and female students choose to major in engineering at similar times in their academic career?
(2) Did the same factors contribute to choosing engineering as a major for both female and male students?

Data for this study was collected in the Fall 2021 semester. The 52-question instrument was approved by consortial IRB from the authors' institutions, as were solicitation and disclosure materials. The survey was administered using Qualtrics, and solicitation material had a link to access the instrument. As of the time of submission, the instrument is not available for additional responses. However, due to the value of longitudinal data and irregularities found in university enrollments during the pandemic, the authors may choose to solicit additional responses at a later date.

The study was conducted at 3 separate institutions, the first is classified as a Master's Large University (enrollment 1800 residential undergraduates, 52% women and 48% men). It is a faith-based liberal arts university located in a metropolitan city. The second is a large metropolitan university classified as a Master's Large University (enrollment 12500, with 62% women and 38% men). The third is a faith-based liberal arts institution located in a mid-sized city. It is an R3 institution with approximately 3500 undergraduates (62% women, 38 % men). All solicited universities have at least one ABET accredited program. For this paper, we did not explore whether the type of institution (size, location, or religious affiliation) has an impact on the major selection process. It is an interesting and relevant question we plan to explore in the future.

Data from the survey was analyzed using a combination of Qualtrics, Microsoft Excel, and SPSS. Due to the nature of the questions in the instrument, most of the responses were collected as nominal, categorical, or ordinal data. As is common for categorical and ordinal analysis, results are presented primarily through visual representations using frequency distributions. Similar presentation techniques were used with nominal variables whenever applicable.

Per IRB approval, minors were not allowed to participate. Both an initial question and another within the study removed participants under the age of 18 and deleted their responses. Partial survey completions were captured as they still provided valuable information for this study.

Findings

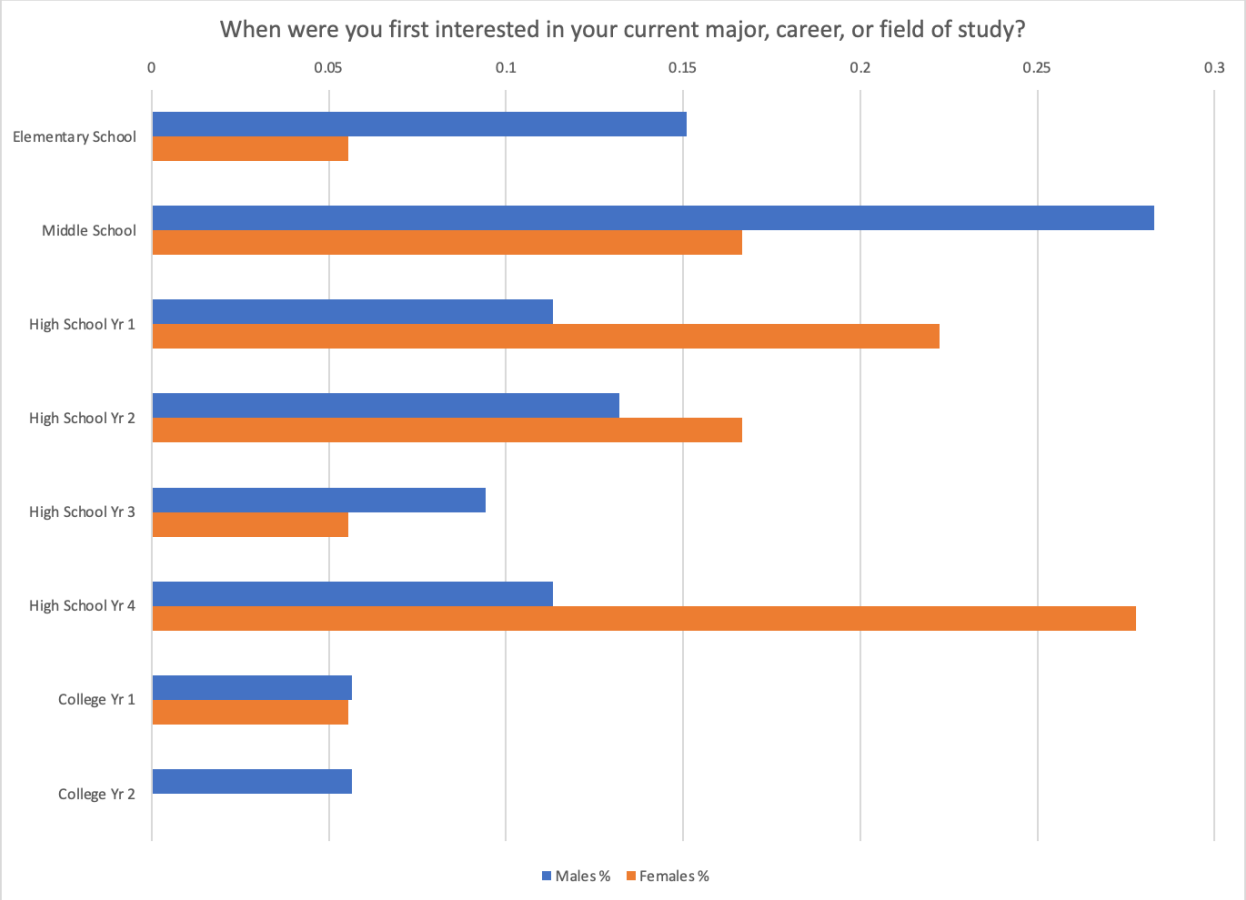
In total, 99 students participated in the survey. They were either currently undergraduate engineering students, or started college as engineering majors. While the number of participants may seem low, this collection and analysis represents the first step in a larger study designed to look at STEM majors in general (not just engineering), and the different gender-biased factors that influence major choice compared to that of other majors across campus.

For the analysis in this paper, we focus specifically on male and female students who are currently engineering majors. Respondents who changed majors after beginning college to a discipline other than engineering were classified separately and a subject for further research. There are 72 respondents from two universities represented in the data; 19 females and 53 males. It is important to note that there were non-binary students who completed the instrument; however, their results were excluded based on IRB guidelines designed to protect confidentiality based on $n<5$. Likewise, students who omitted the gender question or chose "prefer not to answer" were excluded from analysis because they could not be categorized. The large number of males ($n=53$) compared to females

(n=19) was anticipated by the authors, and largely the motivation for this study. In order to compare patterns of behavior across the two groups, our analysis will sometimes report the percentage of respondents rather than count.

To better understand the decision process for selecting engineering as a major, students were asked to identify when they first became interested in engineering and when they actually chose it as their undergraduate major. This sequence of questions was intended to capture major choice as a process that took place over time throughout their educational tenure. The responses to the question "When were you first interested in your current major, career, or field of study" are summarized in Figure 1 below.

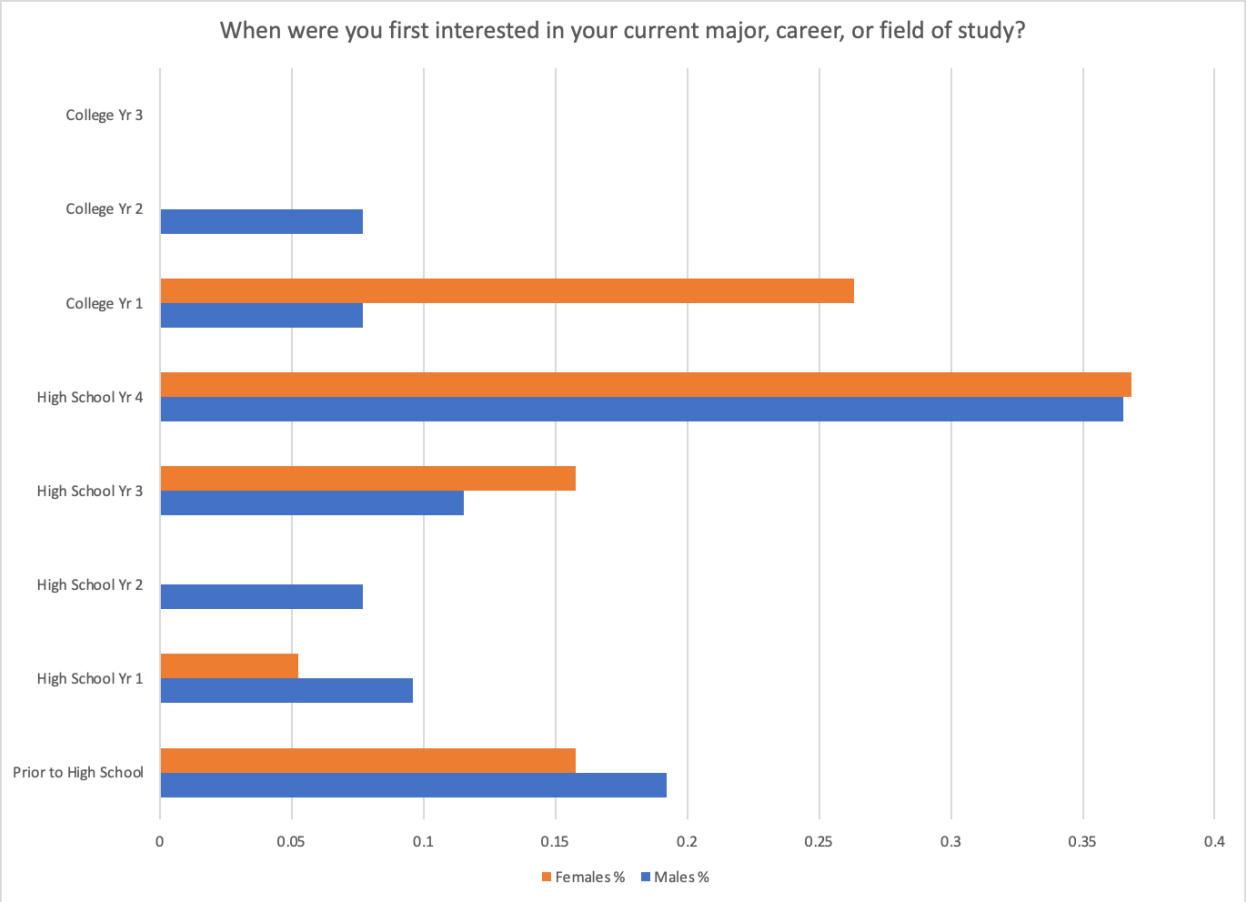
Figure 1: When students became interested in current major, career, or field of study




These responses indicate that female engineering students became interested in engineering as their undergraduate major (4th year of high school) later than their male classmates (middle school). For this survey question, there were responses from 18 females and 53 males.

Next, students were asked when they actually selected engineering as their major. For this question, "Engineering" was a choice available from a list of majors. If a student selected 'Other' but entered an engineering discipline as their major (for example, mechanical engineering) they were reclassified to "Engineering." The results are summarized in Figure 2 below.

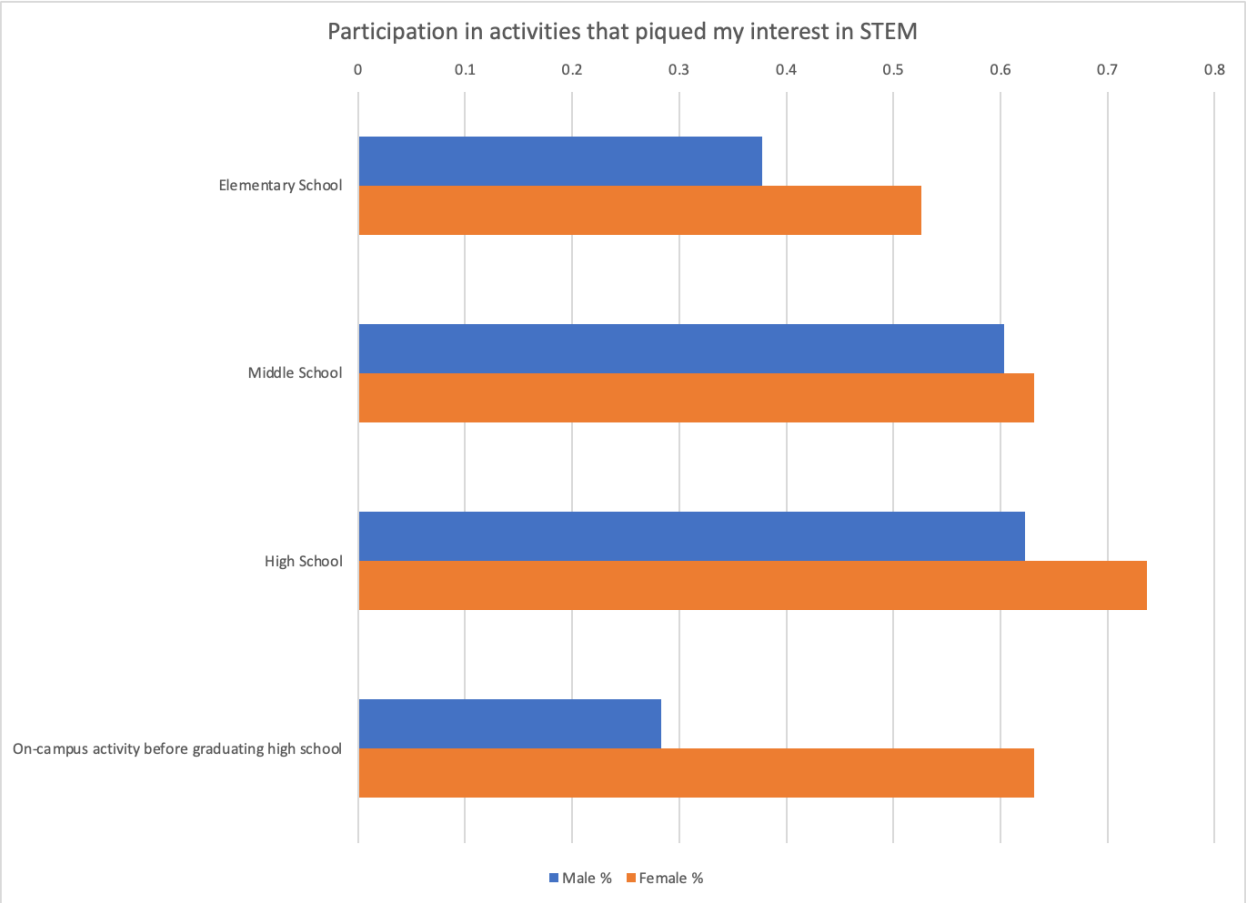
Figure 2: When students selected current major, career, or field of study




Based on responses collected in this survey, female engineering students chose their specific major later in their academic careers than their male classmates. The data shows that almost 70% of female respondents did not choose engineering as their major until their senior year in high school or freshman year in college compared to 45% of males. For this survey question, there were responses from 19 females and 52 males.

The delayed choice among female students is especially interesting as female students actually participated in STEM activities more frequently and earlier than their male classmates; see Figure 3.

Figure 3: When respondents have participated in activities that piqued interest in STEM




Note that in the above graph, responses for each group (male and female) total to more than 100% because this question was a "select all that apply" format, as students could have participated in activities at all or a subset of levels of education.

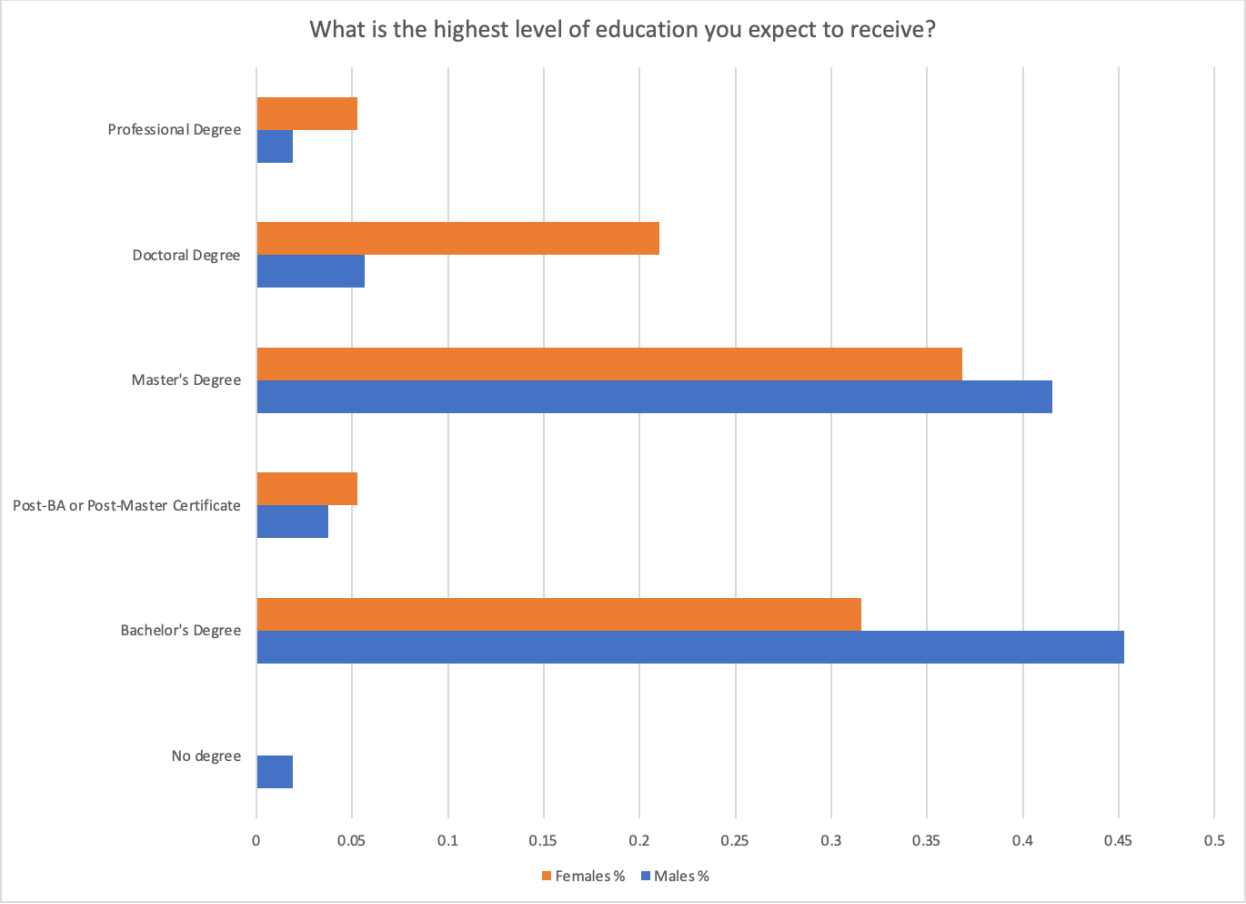
As shown above, more than half of female students reported participating in STEM activities as early as elementary school, and participated at higher rates than their male classmates throughout primary and secondary school. Of particular interest to the authors, over 60% of female students reported that they participated in STEM activities on college campuses, over twice as much as their male classmates. These trends display the aforementioned efforts to increase female participation in STEM fields, but may also create a competitive environment for female students with academic aptitudes common across STEM fields.

In addition to understanding when engineering students selected their majors, the authors examined why students selected their majors. Malgwi, Howe, and Burnaby (2005) found that male students choose majors based on potential career options, while female students

choose majors based on academic ability. The responses of this survey do not confirm that finding, as little difference was found between male and female students.

For example, students were asked who (parent, mentor, faculty member, etc) influenced their choice in major. There was no observable difference based on gender. However, there was great disparity when asked about anticipated educational goals. Students were asked their highest anticipated degree. As shown below in Figure 4, female engineering students reported that they were three times as likely as their male classmates to anticipate earning doctoral degrees. This suggests that the decision process is not only gender biased when choosing a major, but may also be when exiting one.

Figure 4




Conclusion

In this paper, we examined when undergraduate students began to gain interest in their selected major and who or what was influential in that process at three unique institutions through a survey instrument developed based on past research.

Data from the survey suggest that although female students were more likely to be exposed to STEM activities early on in their education when compared to their male counterparts, female students on average indicated that they chose their major as engineering later. Additionally, female engineering students reported that they were 3 times more likely as their male classmates to anticipate earning a doctoral degree.

While the study has so far yielded meaningful insights into differences in the major selection process of male and female students, including a contrast with previous research regarding gender differences in motivation for selecting a major, it has also raised additional questions based on responses found in the data. The authors intend to investigate whether students leaving engineering as a major exhibit patterns of major selection and influences that are different from those for students who graduate with an engineering degree. Second, the authors wonder if similar major selection patterns and influences are found in STEM fields outside of engineering. And finally, given that in our survey data the majority of students who left engineering as a major changed to a business major leads to the question: do similar patterns of gender biased decision processes exist in business fields as well?

While many efforts have been made to increase the number of females in STEM, engineering continues to lag behind medicine and other STEM careers. It is our hope that the results of this study will lead to further research to investigate why, despite being exposed to STEM activities earlier, they commit to an engineering major later than their male peers.

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