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Assessing Gender Differences between Student Motivations for Studying Engineering

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Abstract

This research paper investigates what motivates students to major in engineering, and how the motives differ between men and women. It aims to address curriculum planning in first-year engineering programs to improve retention and diversity. Previous research has identified course practices – such as team-based projects – that have positively impacted engagement of women in engineering. Understanding the motivations for students to choose engineering can connect the reasons why certain curricular practices resonate with student desires. These reasons can be integrated into course projects. A literature review and analysis of essay responses were used to generate a series of motivations to investigate. A Likert scale survey relating these motivations to reasons that students chose engineering was conducted in first-year engineering courses. A scale of altruistic to individualistic motivating factors to major in engineering was evaluated for appropriateness to this discussion on differences between men and women. A statistically significant difference was found in a desire to help society, previous engineering experience, and career opportunities.

Introduction

Recent studies have investigated the differences in motivation for choosing particular majors in engineering. This study aims to add another dimension to differentiate student motivations based on gender. A multidisciplinary first-year engineering design course and a discipline-specific introduction to civil engineering course are used for this study. The discipline-specific course reveals within-discipline variation of motivations, while the multidisciplinary course can be used as a basis for evaluating between-discipline variations. This comparison can be used to determine if curriculum should be reevaluated on a discipline-specific basis or standardized across all fields of engineering. Although some preliminary differences are seen between majors, this paper focuses on differences between men and women to quantify why women choose to major in engineering.

The reason for focusing on women motivations to choose engineering is the continuing underrepresentation of women in undergraduate engineering programs, leading to a low percentage of women earning bachelor's degrees in engineering. Data collected by the American Society for Engineering Education show that the percent of women earning BS degrees in engineering has increased slightly between 2009 and 2014, from 17.8 percent to 19.9.[1] A greater effort is needed to continue increasing the number of women receiving bachelor's degrees in engineering.

One of the leading institutions in female engineering enrollment, Carnegie Mellon, reports that 30% of their engineering students are women.[2] Female engineering enrollments at other major universities are lower: 20% at Ohio State,[3] 27% at UT Austin,[4] 24% at NYU,[5] 26% at UC

Berkeley,[6] and 28% at Georgia Tech.[7] It is suspected that the low enrollment numbers are a result of social issues and curricular policies. While social change is outside the scope of higher education faculty control, curriculum changes can be used to encourage women as well as retain them in engineering programs.

There is evidence that certain curriculum practices are more enticing to women and motivate them to stay in engineering. Strategies to attract women to engineering have included teamwork, service projects, and social impacts of engineering projects. These strategies reflect the higher percent of degrees awarded to women in areas like environmental and biomedical engineering, 48% and 40%, respectively, compared to 20% of all bachelor engineering degrees awarded to women[1]. The results of a survey of motivations to choose to major in engineering can reveal the importance of these strategies to women.

Literature Review

Several studies have investigated the reasons that students choose to major in engineering. They were often motivated by recruitment practices and techniques to improve retention. This paper will identify techniques and findings in the literature to provide context for a similar study focusing on differences between men and women. The goal of this research is primarily curriculum development in areas that will engage women. Based on previous studies the results of engaging students with their interests will improve retention, but retention is not measured in this paper.[8] Common techniques for investigating the motivations behind entering engineering include text analysis of essays on why students chose engineering and Likert scale survey questions including a statistical comparison, Wilcoxon rank-sum test, of results for different groups.[9] This research used both techniques: text analysis of essays guided the development of a Likert scale survey which was quantitatively analyzed.

A number of motivations have been investigated for why students choose engineering. Many studies have identified negative motivators to be important. Negative motivations represents reasons that students feel obligated to complete their degree or to avoid engineering altogether. These include concerns over the ability to earn a degree, self-efficacy, or the effort required to attain a degree.[10] Another study revealed the desire for a student to fit in the standard definition of an engineering student or self-identify as part of the program.[11] Others have addressed parental pressure or financial need as issues for wanting to study engineering.[12] Since many of these negative motivators are less apt to be addressed by curriculum changes, this paper will focus on positive motivators.

Positive motivations can be further classified into a spectrum of altruistic reasons. Evidence has shown that social responsibility can play a large role in students motivation to choose a major.[13] The most common responses from students was a desire to have a positive impact on society or to help the environment.[12,13,14] Other responses showed a strong interest in working on multidisciplinary teams to solve real world problems. These reasons have been labeled as altruistic to determine if there is a trend between inward and outward goals amongst students.

Some reasons are neutral with respect to altruism. For instance, having family members in the field of engineering.[13,14] Although a person's family members' profession is outside the scope of curriculum, it can be used to eliminate if this was a student's primary reason to be in engineering, since it is a commonly occurring response. Another neutral reason could be if the student has previous personal engineering experience outside of class.[13,14] There is a potential for their previous work to be explored more thoroughly in the curriculum of a new course project.

Other positive motivations can be classified as individualistic. These reasons are closely related to psychological enjoyment or behavioral preferences. The common student responses in this category are being good at math and science, liking to build a final product, and understanding how things work.[10,11,13,14] Behavioral reasons have been shown to be the most popular, which is why they should be classified into subcategories like the ones above to determine what is more important. The individualistic reasons, or the opposite end of the altruistic spectrum, are often referred to as utilitarian. This includes career opportunities and earning potential. A desire for these skills can be used to indicate the importance of training students on professional aspects.

There are several differences across disciplines with regards to reasons to choose engineering. First-year engineering students are more certain of choosing engineering as a whole compared to choosing what discipline within engineering.[9] First-year engineering courses also help students determine their interests in the different engineering disciplines.[15] Other sources of information that students commonly use to decide on a discipline include personal exploration, peer discussion, and advice from professors.[16] Primary difference between majors in the first year have been classified for civil, environmental, and mechanical. Students entered civil engineering to build things, environmental engineering to help the environment, and mechanical engineering because they like math and science. Both civil and environmental engineering students changed their mind in their senior year and felt that an impact on society was the most important.[13] Differences seen between disciplines appear negligible for men, but can vary for women.[17]

There have been limited findings on the details of gender differences for choosing engineering. Several studies have found women place a higher value on motivation from mentor or parental influence.[12,17,18] These studies have also found that men are more motivated to study engineering by intrinsic behavior.[12,17] Each of these findings provides insight into the potentially important differences behind motivation to be in engineering.

A few common constructs have been used for gender differences. The studies on intrinsic behavior are based on the Academic Pathways of People Learning Engineering Survey (APPLES).[12,17,19] Motivational factors included in the APPLES construct were financial, parental, social good, mentor, psychological, and behavioral.[12,17,19] Another construct, the Achievement Goal Theory, focuses on curriculum that promotes intrinsic values, processes, treating uncertainty as opportunity, accurate assessment, and rewarding effort. [20] This is similar to the Expectancy-Value Theory, which focuses on success, difficulty, interest, usefulness, attainment, and cost. [11] These constructs includes several administrative issues that are not as

important for curriculum development, so a separate survey was created for this paper based on potential curriculum topics and projects.

Methods

The method for collecting the data reported in this paper combines procedures used in other studies of motivation for choosing engineering. Analysis of essay responses from four semesters of an introduction to civil engineering course revealed that there are several common motivations that students will self-identify for deciding to major in civil engineering, and also revealed different patterns of responses from male and female students. This led to the decision to develop a Likert scale survey which produces data that is more amenable to statistical analysis. The pool of students was also expanded to include students in other majors; this increased the sample size and also offered the opportunity to evaluate differences between majors.

A comparison of the motivations stated in the essays with the motivations frequently cited in the literature helped to generate the list of motivations. This list was included in the Likert scale survey constructed for this research. The process of developing the list of motivations to include in the survey is indicated at the top of Figure 1. Unlike the essay prompt which did not provide a list of motivations to choose from, nor instructions to quantify the relative importance of each motivation, the survey needed to list a selection of possible student motivations and ask for relative importance of each. The motivations used in the survey were selected based on applicability to all disciplines and their ability to influence curriculum development. The motivations are shown in Table 1. In addition to the general Likert prompt “Indicate the degree to which each of the statements below motivated you to major in engineering” for each of the motivations, a final question asked each student to identify which of the ten listed motivations most influenced his/her decision to major in engineering. Two control questions asking the student’s major and gender were used to evaluate how responses vary across these populations.

The survey was administered to students in five sections of a multidisciplinary first-year engineering design course and a single section of a discipline-specific introduction to civil engineering course. The total number of respondents was 104; the breakdown by major and gender is presented in Figure 1. The variables n_f and n_m stand for number of female and number of male respondents, respectively, within each major. The number of male and female respondents is a large enough sample to provide statistical significance based on a rule of thumb, that is, the number is greater than 30. However, the number within each major is too low to draw conclusions about gender differences within major.

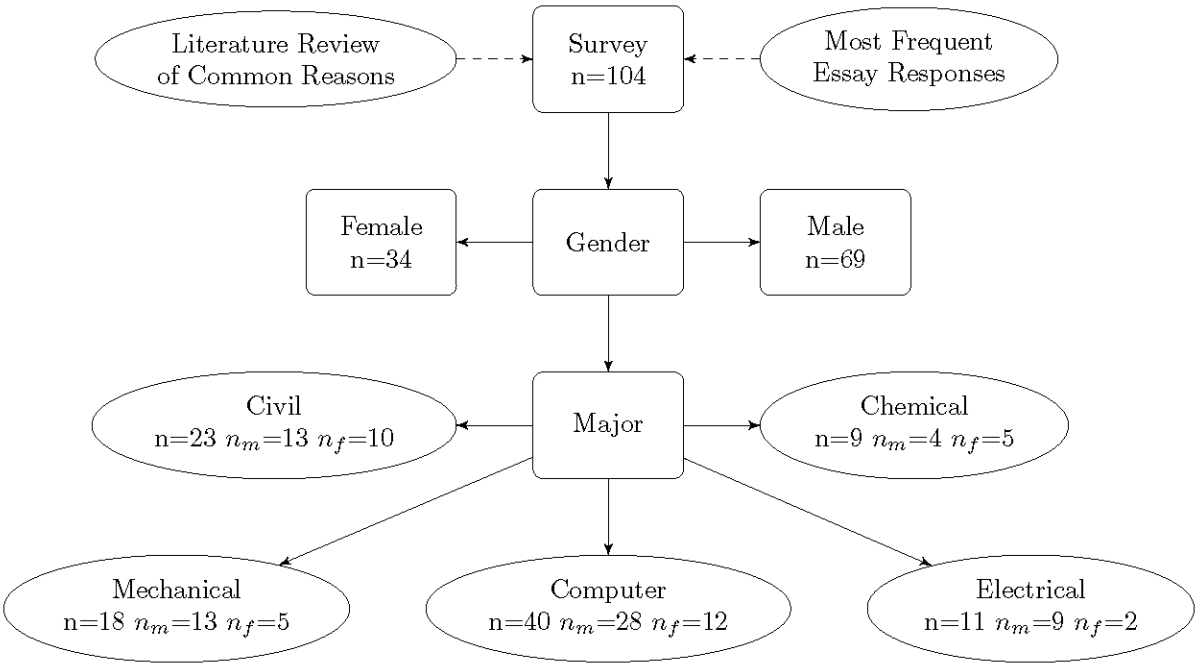

Figure 1: Likert Scale Survey Development and Dissemination Characteristics

A few discrepancies in the data totals in Figure 1 are a result of unanswered questions. One student did not respond with a gender. Two students did not respond with a major. A female student did not include her top choice for the motivations to major in engineering.

Likert scale surveys are a common technique for quantifying the importance of motivators for students. As indicated in Table 1, a Likert scale using five responses from strongly agree (5) to strongly disagree (1) was used; this common choice is a balance between the extremes of a 3 point and 7 point scale. Validity of a Likert scale survey should be addressed by calculating Cronbach's Alpha.[21] The best method for investigating responses to a Likert scale questions is a frequency response. Speculation about potential differences in responses between two populations can be determined using the Wilcoxon rank-sum test, also known as the Mann-Whitney U test.[22] For this research, the data were collected using a Qualtrics survey emailed to students at the beginning of a class period. Basic statistical analyses and frequency responses were calculated in a spreadsheet, Cronbach's Alpha test was performed in Stata, and Wilcoxon rank-sum tests were run in MATLAB.

Table 1: Likert Scale Survey Questions for Student Motivations to Major in Engineering

Likert Prompt	***Reason***
Indicate the degree to which each of the statements below motivated you to major in engineering. ***Strongly Agree = 5*** ***Agree = 4*** ***Neutral =3*** ***Disagree = 2*** ***Strongly Disagree = 1***	I want to have a positive impact on society.
	I am interested in helping the environment.
	I want to work on multidisciplinary teams for broader applications and to make a bigger impact.
	I like to solve problems.
	I have family members that are part of this industry.
	I have previous personal engineering experience outside of school.
	I like building things and being able to see the final product.
	I am interested in how things work and operate.
	I like to apply my strong math and science skills.
	I desire to have career stability and earning potential.

As mentioned in the literature review it is useful to classify student motivations on a scale from outward to inward influences. The organization of the motivations along this scale is shown in Figure 2. Motivations with outward focus toward society and the environment are on the altruistic end of the spectrum. Conversely, career goals and a love of math and science are identified as inward-focused individualistic motivations; career goals benefit primarily the student, and choosing math- and science-related majors are a result of personal feelings.

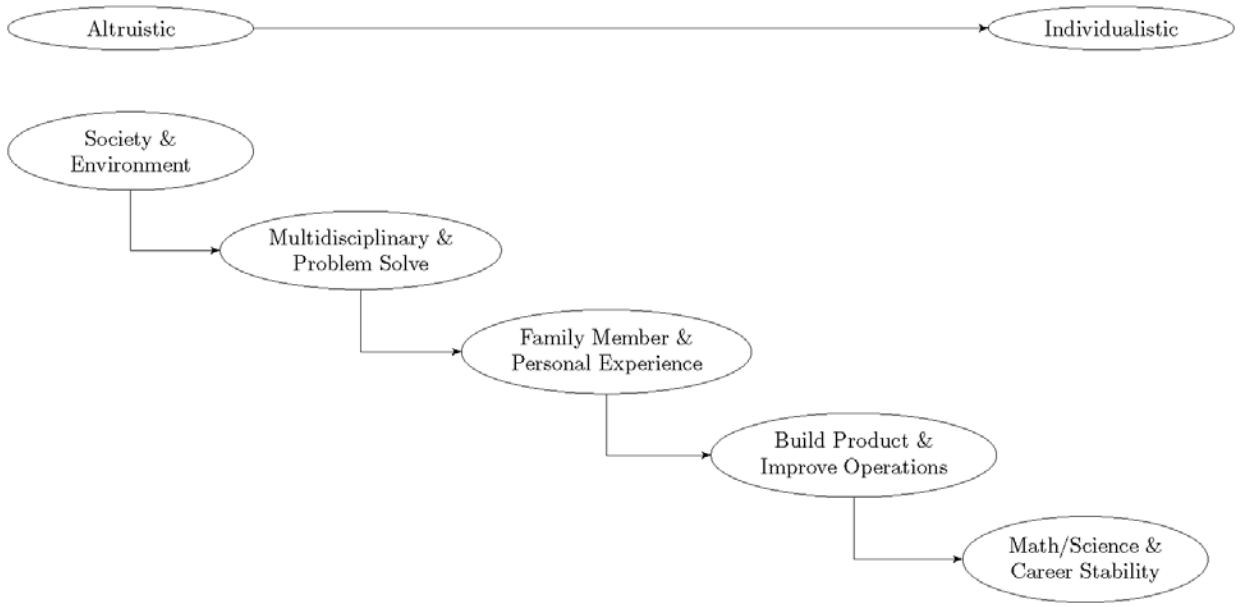

Figure 2: Altruism Scale for Reasons to Choose Engineering as a Major

The intermediary motivations can also be placed on this scale. A desire to work on multidisciplinary teams and solve problems indicate that students are interested in collaboration

with others and want to address issues in communities. These reasons are closer to the altruistic end of the spectrum. A relatively neutral reason, in terms of altruism, is personal or familial experiences with engineering. A desire to build products and understand how things work are individualistic because they are related to behaviors and interests. The degree of altruistic or individualistic nature helps to provide a frame of reference for each of these motivations to major in engineering.

Analysis of Results

The results of this survey have been examined using a number of established methods; the analytical methods and relevant figures and tables are summarized in Table 2. A graphical comparison of the motivations stated in the essays and the average Likert scores for the same motivations is presented in Figures 3 and 4. Figure 5 shows the primary motivation selected by each student in the final survey question. Tables 3 and 4 separate the results in Figure 5 into percent breakdown by gender and by discipline, respectively. A frequency chart showing the percent of students' responses to all questions is presented in Figure 6. The statistical comparison results of the gender responses using the Wilcoxon rank-sum test is summarized in Table 5. Gender and discipline breakdown for statistically significant gender differences are shown in Figures 7 through 9.

Table 2: Summary of Analysis Methods for the Essay Responses and Likert Scale Questions

Analysis	***Test***	***Figure/ Table***
Essay Responses Comparison to Survey Responses	Compare percent of essays including a motivation versus average Likert score	F3&F4
Top Motivations in Surveys	Graph top motivations for all students	F5
Tabulate Top Choices by Gender and Major	Calculate percentages of gender and major that selected a top motivation	T3&T4
Likert Results for All Students	Diverging stacked bar chart of frequency distribution for all majors and genders	F6
Statistical Comparison between Genders	Wilcoxon rank-sum Test for statistical significance between Likert averages for gender per question	T5
Likert Results for Questions with Differences	Diverging stacked bar chart of frequency distribution for questions with differing responses between genders and majors	F7-F9

Results based on the civil engineering essays, seen in Figure 3, show potential gender differences. Although civil engineering students of both genders express a strong desire to help society, a larger percentage of female students are motivated by an interest in the environment. Women also appear to have a greater draw to working on multidisciplinary teams. It was these distinct differences in response patterns that led to the development of the Likert survey which permits statistical interpretation of results. Since the Likert survey was only conducted during one semester and only 23 civil engineering students participated, the small sample size precludes

presentation of discipline-specific results with any degree of confidence in their statistical reliability. Therefore, the remainder of the analyses in this paper focus on the overall gender differences between engineering students in all majors.

When comparing the results of the essay responses in Figure 3 to average Likert scale responses in Figure 4 it is important to note that only civil engineering students were required to complete the essay assignment. Furthermore, the procedural differences of collecting the data are significant. The students writing the essays were not prompted with a list of motivations; some mentioned numerous motivations in their essays while many only limited themselves to one or two, but without a means of comparing degree of motivation. Most of the same gender differences are seen in a comparison of Figure 3 and Figure 4, that is, the average Likert scale responses are consistent with the number of times a motivation was mentioned in an essay. Only two motivations show a difference between the essay and survey results. In the survey responses, in Figure 3, women were more motivated than men by working on multidisciplinary teams, and the opposite is true in the average Likert scale response, in Figure 4. In the essay responses men were more interested in having an impact on society, while the survey results indicate women are more interested in helping society. All other gender differences in motivating reasons were consistent between the essay responses and survey responses.

Figure 4 shows the average of all student responses to the ten Likert scale questions asking the degree to which each motivation influenced a student to major in engineering. While presenting averages in this manner is quite common, the literature notes the inappropriateness of reporting an average Likert scale response. Since the data is ordinal the average does not always have a direct meaning. For instance, the average of two responses, one “strongly agree” (5) and the other “strongly disagree” (1), results in a “neutral” (3) designation when, in reality, two extreme responses do not represent a neutral sample. However, the average responses are reported in Figure 4 for reference and in Table 5 for statistical test results.

When comparing Figures 3 and 4, it is also important to note that a Likert scale response of 3 is neutral, meaning that a stated motivation did not influence a student’s decision to major in engineering. Therefore, a Likert scale average of 3 or less should correspond to a motivation that is not listed in a student essay. Figure 3 shows that students mentioned family members’ involvement in the field and prior personal experience with engineering least often their essays; these are the two motivations that earned Likert scale averages less than 3. The career and financial prospects were also infrequently cited as motivations by the civil engineers in their essays but the Likert scale averages for this motivation were approximately 4.5; this could be attributed to the fact that many students have been coached during the college application process to write essays that provide more substantive responses that address the job attributes they seek. Note that Figures 3 and 4 only include eight of the ten motivations that were included in the survey because two of the survey motivations were not extracted from the essays when they were screened.

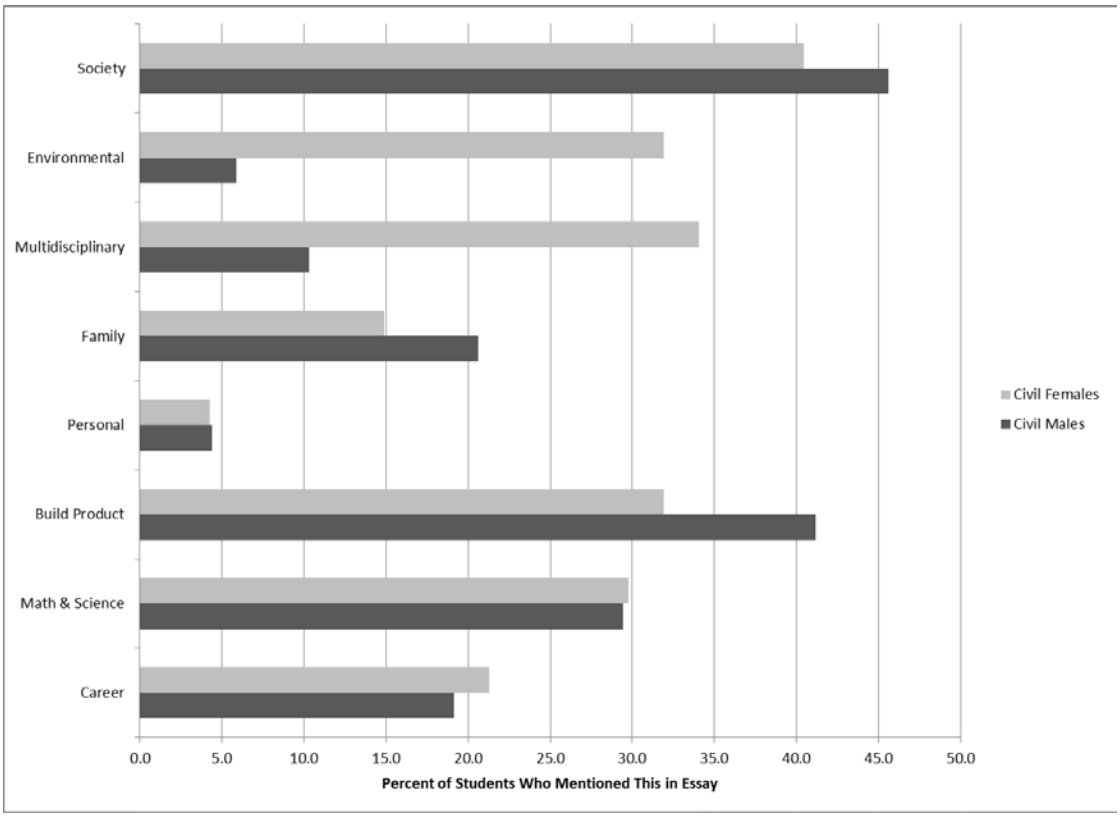

Figure 3: Percent of Student Essay Responses Containing Reason by Gender

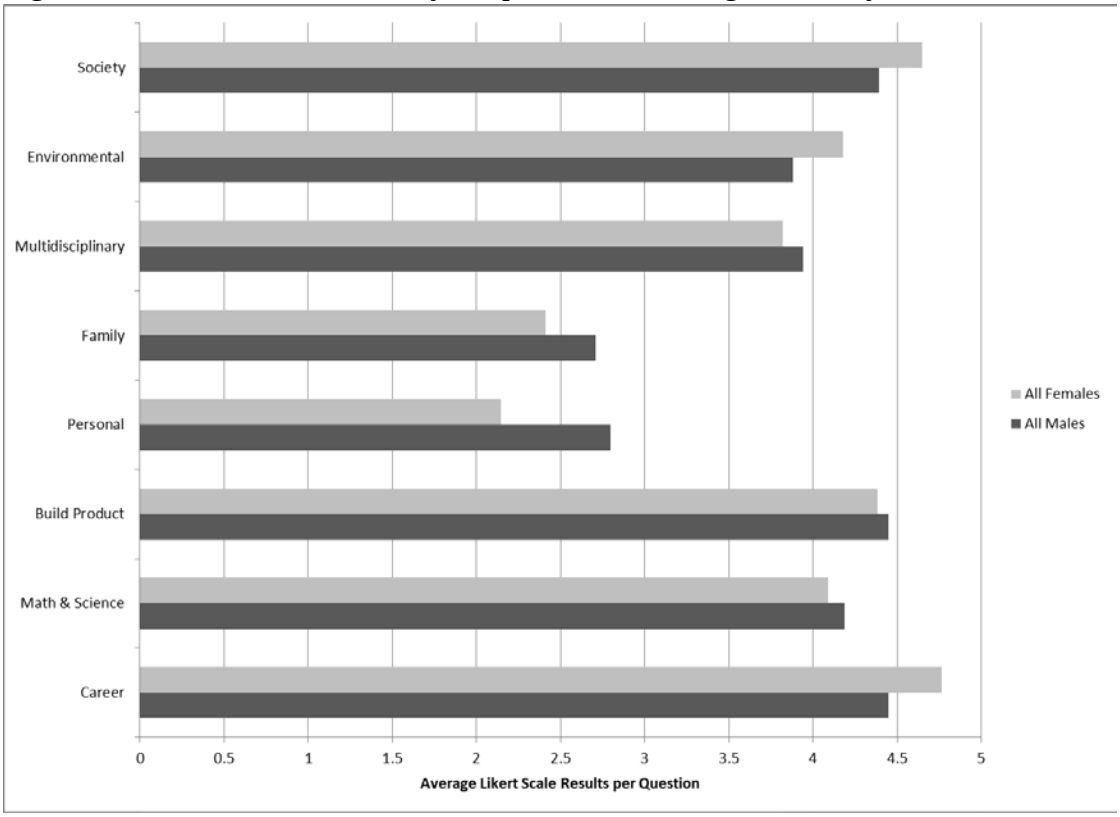

Figure 4: Average Likert Scale Results for Each Reason by Gender

The final question of the survey asked students to select the motivation that most influenced their decision to major in engineering. This can be a difficult question for many students to answer, because many students' decisions are influenced by a set of factors. Nevertheless, Figure 5 shows the response to this question. The most frequently selected motivation is the altruistic interest in helping society, followed closely by an interest in building things. Both of these motivations also have high Likert score averages, indicative of consistency in student responses. The authors were surprised by the small number of students who were primarily motivated by their math and science skills, because of the authors' perception that many high school guidance counselors use math and science as a criterion to suggest engineering as a career option. The very small number of students who indicated that their primary motivation is interest in helping the environment was also unexpected; however, this survey included only a small number of civil and chemical engineers, majors which tend to prefer to focus on environmental problems.

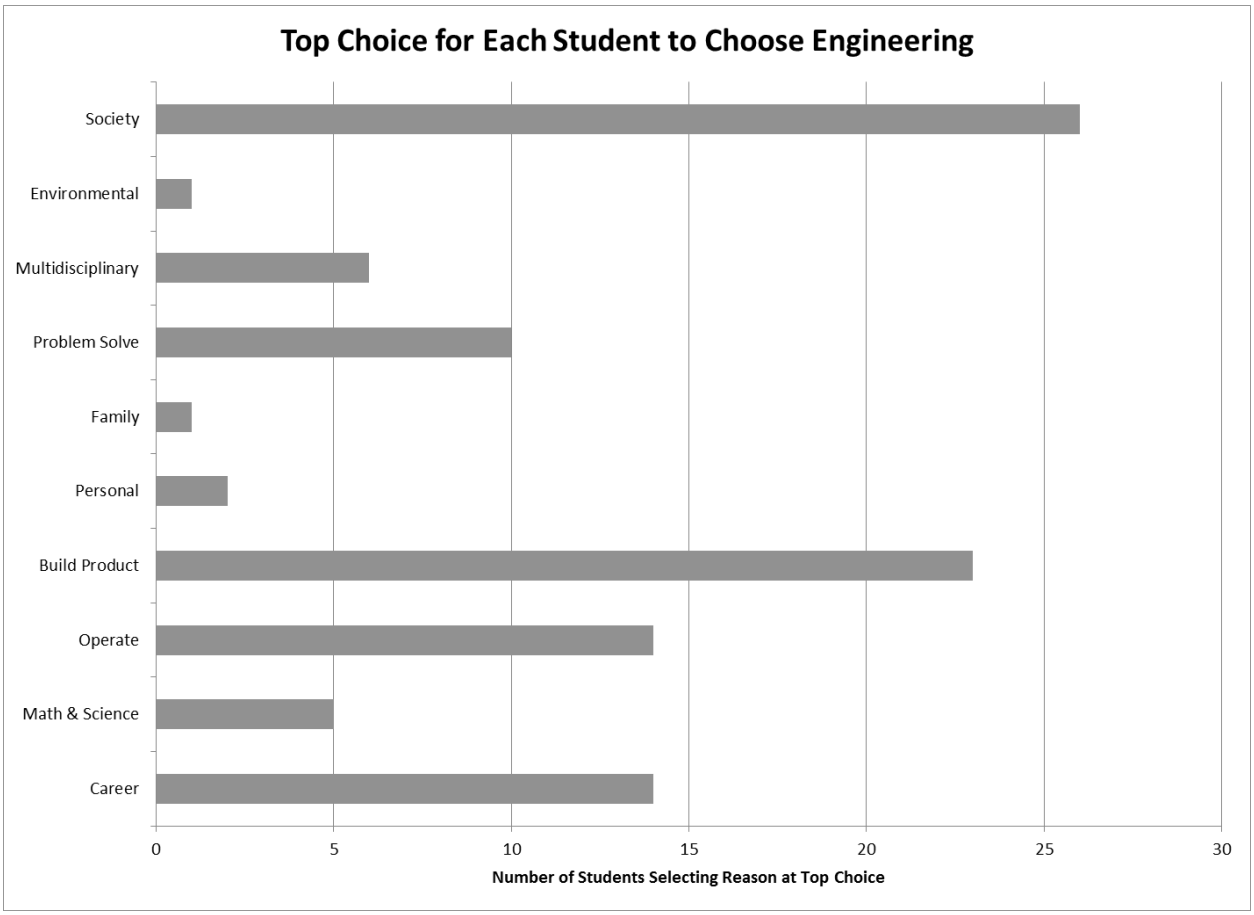

Figure 5: Top Responses for All Students for Choosing to Major in Engineering

Table 3 agrees with Figure 4; both reveal an altruistic interest in helping society as a motivation for majoring in engineering. Furthermore, the differences between male and female motivation by the multidisciplinary nature of engineering (of interest to more females) and ability to build a final product (of interest to more males) is consistent with the responses in the civil engineering

essays, in Figure 3. The small number of students who select interest in helping the environment are all female. This is once again consistent with female civil engineering students' essays.

Table 3: Top Responses by Gender for Choosing to Major in Engineering

Reason	*Male*	*Female*	*Total*	*Men %*	*Women %*
I want to have a positive impact on society.	18	8	26	**26.09%**	**24.24%**
I am interested in helping the environment.	0	1	1	0.00%	3.03%
I want to work on multidisciplinary teams for broader applications and to make a bigger impact.	3	3	6	**4.35%**	**9.09%**
I like to solve problems.	5	5	10	**7.25%**	**15.15%**
I have family members that are part of this industry.	1	0	1	1.45%	0.00%
I have previous personal engineering experience outside of school.	2	0	2	2.90%	0.00%
I like building things and being able to see the final product.	18	4	22	**26.09%**	**12.12%**
I am interested in how things work and operate.	10	4	14	14.49%	12.12%
I like to apply my strong math and science skills.	4	1	5	5.80%	3.03%
I desire to have career stability and earning potential.	8	7	15	**11.59%**	**21.21%**
Total	69	33	102	100%	100%

Table 4 breaks down the primary motivation data by discipline. Both of the top responses noted in Figure 5 show considerable variation across the majors (shown in bold font in the table). With the small sample size of each discipline (ranging from 9 chemical engineers to 40 computer engineers) it is difficult to draw any strong conclusions without relying on anecdotal information.

Table 4: Top Responses by Discipline for Choosing to Major in Engineering

Reason	*Civil*	*Chem.*	*Comp.*	*Elec.*	*Mech.*
I want to have a positive impact on society.	**30.4%**	**44.4%**	**12.5%**	**50.0%**	**22.2%**
I am interested in helping the environment.	4.3%	0.0%	0.0%	0.0%	0.0%
I want to work on multidisciplinary teams for broader applications and to make a bigger impact.	0.0%	0.0%	7.5%	0.0%	16.7%
I like to solve problems.	0.0%	22.2%	10.0%	8.3%	16.7%
I have family members that are part of this industry.	0.0%	0.0%	2.5%	0.0%	0.0%
I have previous personal engineering experience outside of school.	0.0%	0.0%	5.0%	0.0%	0.0%
I like building things and being able to see the final product.	**39.1%**	**0.0%**	**20.0%**	**8.3%**	**22.2%**
I am interested in how things work and operate.	8.7%	11.1%	15.0%	16.7%	16.7%
I like to apply my strong math and science skills.	4.3%	0.0%	7.5%	0.0%	5.6%
I desire to have career stability and earning potential.	13.0%	22.2%	20.0%	16.7%	0.0%
Total	100%	100%	100%	100%	100%

Returning to the Likert questions, Figure 6 shows a frequency diagram for the response to each motivation. This visual representation of the data provides a more detailed understanding of the responses. All of the bars are stacked to align the centers of the neutral response category. A bar extending far to the right indicates that most students were motivated by the listed factor and a bar extending further to the left indicates that more students were not motivated by the listed factor. The figure reveals that the potential error introduced by averaging extremes did not occur.

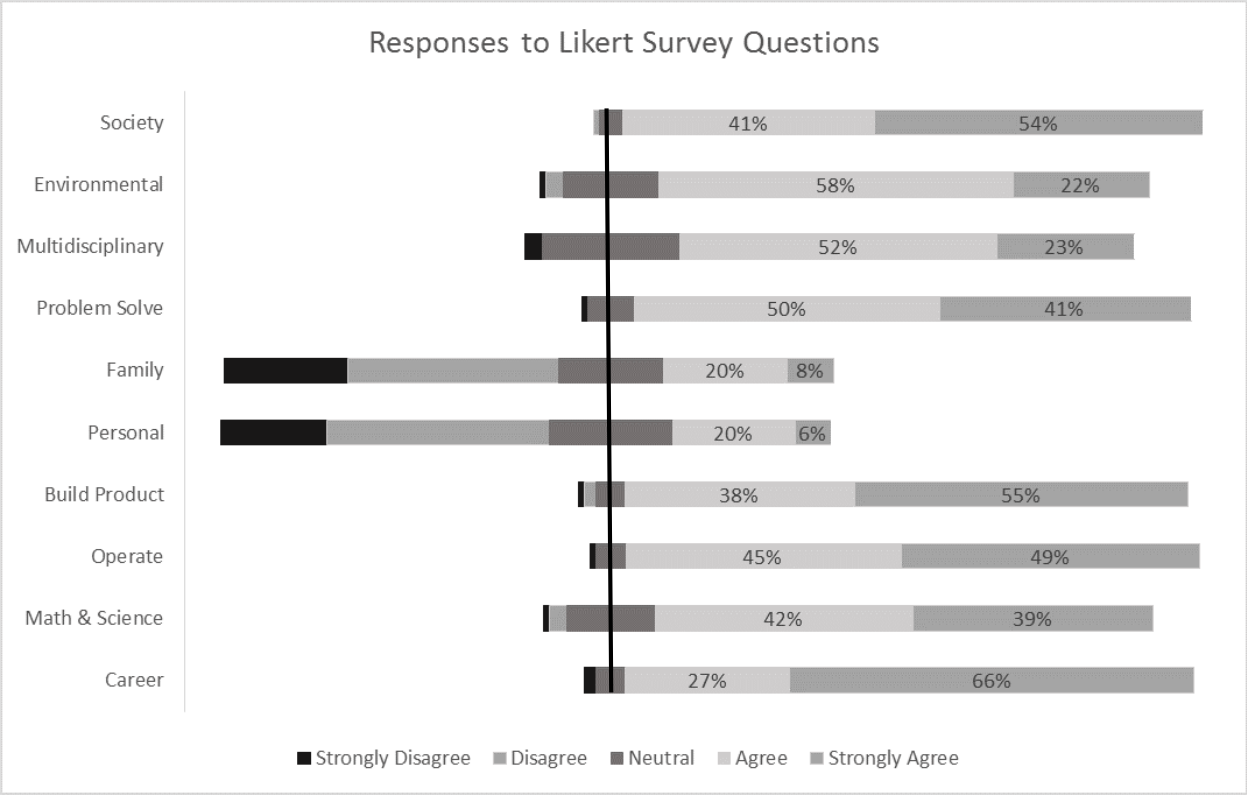

Figure 6: Frequency Chart of Percent Likert Responses to Each Question

Common practice when developing a survey with Likert scale responses is to validate the scale used for the responses. Reliability analysis provides a measure of internal consistency of the survey questions. In particular, calculating Cronbach's Alpha will determine if the scale used in the survey provides meaningful answers to the underlying characteristics being studied. The overall Cronbach's Alpha for this survey is 0.781, which is considered acceptable to good.

The Wilcoxon rank-sum test, also called the Mann-Whitney U test, is a non-parametric test which can be used to compare the distributions of two independent samples of ordinal responses. Using the male and female students as independent populations in this study, the Wilcoxon rank-sum test was used to determine if the distribution of responses to each Likert question was statistically the same or different for each gender.

In statistical terms:
H_0: x and y are two sample dataset that have distributions with equal medians

$$P(X > Y) = P(Y > X)$$

H_A: x and y have distributions such that the probability a data point in x being greater than a data point in y, is different from a data point in y being greater than x

$$P(X > Y) \neq P(Y > X)$$

The practical definition for this research:
H_0: Men and women have a similar opinion toward the motivation for studying engineering
H_A: Men and women feel differently about the motivation for studying engineering

Table 5 provides the results of the Wilcoxon rank-sum analysis. For reference, the Likert averages are also tabulated by gender, along with the absolute value of the difference between male and female averages for each motivation. The statistical analysis reveals that male and female students attribute a different range of influence of three of the motivations that were included in the survey: interest in helping society, previous personal experience, and career factors all are viewed differently at the 5% significance level. Female students have a statistically significant greater interest in helping society and in career goals, while male students have been influenced by prior engineering experiences to a greater extent.

In the Wilcoxon rank-sum analysis, a p-value of less than 0.05 indicates a rejection of the null hypothesis. This suggests that the distribution of Likert responses differs between men and women for these motivations. Or, the absolute difference in the averages is significant.

Table 5: Statistical Comparison of Responses by Gender

Reason	*Male Likert Average*	*Female Likert Average*	*Absolute Difference*	*P Value Rank Sum*
I want to have a positive impact on society.	**4.391**	**4.647**	**0.256**	**0.034***
I am interested in helping the environment.	3.882	4.176	0.294	0.061
I want to work on multidisciplinary teams for broader applications and to make a bigger impact.	3.941	3.818	0.123	0.216
I like to solve problems.	4.275	4.353	0.078	0.680
I have family members that are part of this industry.	2.710	2.412	0.298	0.329
I have previous personal engineering experience outside of school.	**2.797**	**2.147**	**0.650**	**0.015***
I like building things and being able to see the final product.	4.449	4.382	0.067	0.226
I am interested in how things work and operate.	4.388	4.441	0.053	0.677
I like to apply my strong math and science skills.	4.188	4.088	0.100	0.549
I desire to have career stability and earning potential.	**4.449**	**4.765**	**0.315**	**0.032***

* Indicates that the difference is statistically significant

Frequency diagrams for these three motivations are presented in Figures 7 through 9, with breakdown by both gender and by major. Figure 7 corroborates the statistical difference we see between men and women for their motivation to major in engineering as an opportunity to help society. A larger percentage of women strongly agree with the statement that helping society was a motivating factor for choosing engineering.

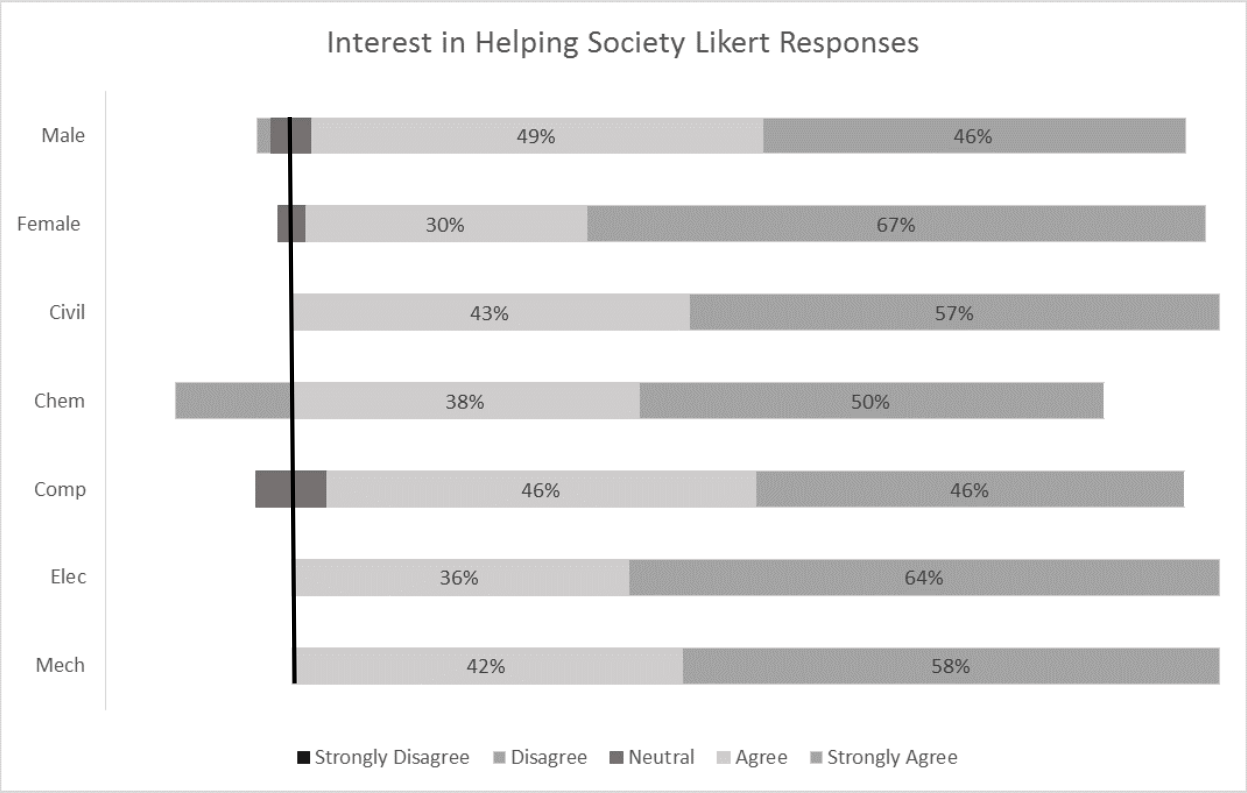

Figure 7: Frequency Chart of Percent Likert Responses for Society by Gender and Major

Figure 8 also indicates the same results of the statistical analysis of the Likert response averages. Not only did no women strongly agree that previous personal experience drew them into engineering, but fewer women than men agree with this motivation. It also interesting to note that a much greater percentage of women strongly disagree that personal experience was a reason for majoring in engineering.

Figure 9 demonstrates less of a difference across genders and majors. However, it shows that more women strongly agree with career opportunities being a motivator for becoming an engineer.

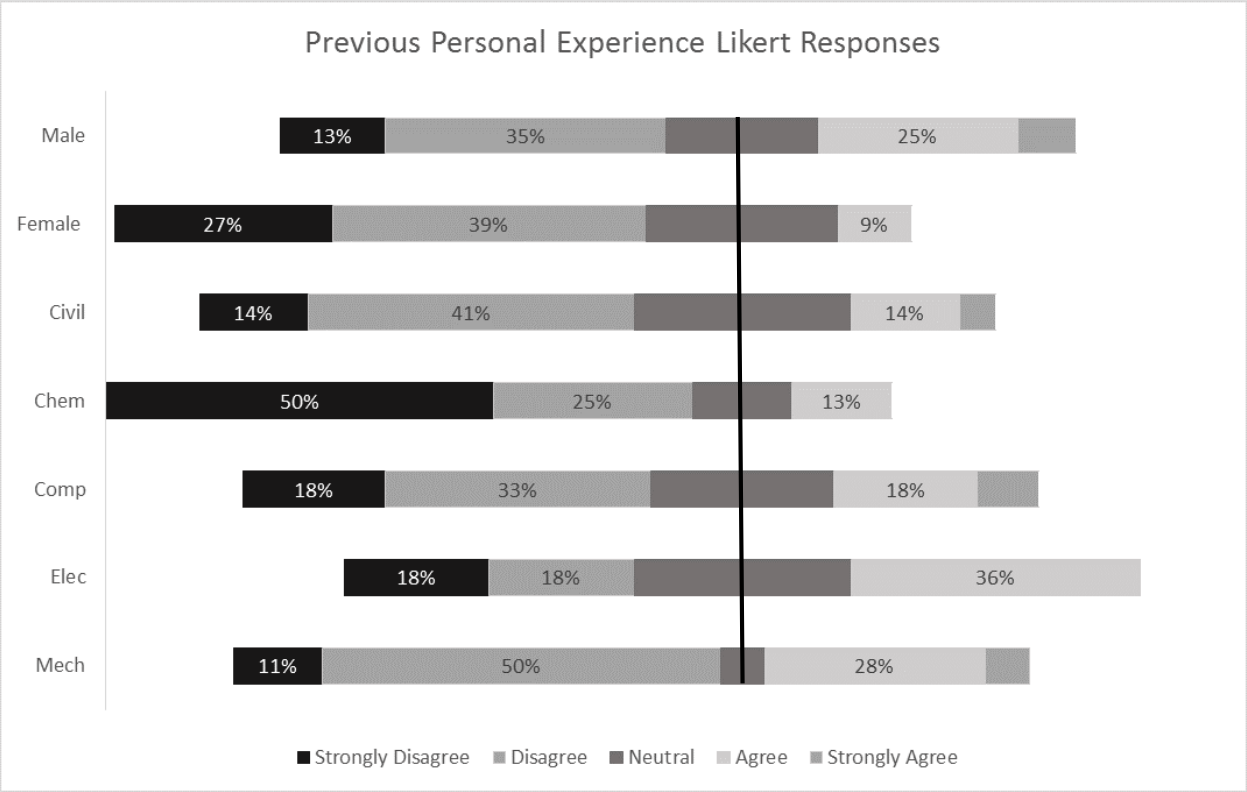

Figure 8: Frequency Chart of Percent Likert Responses for Experience by Gender and Major

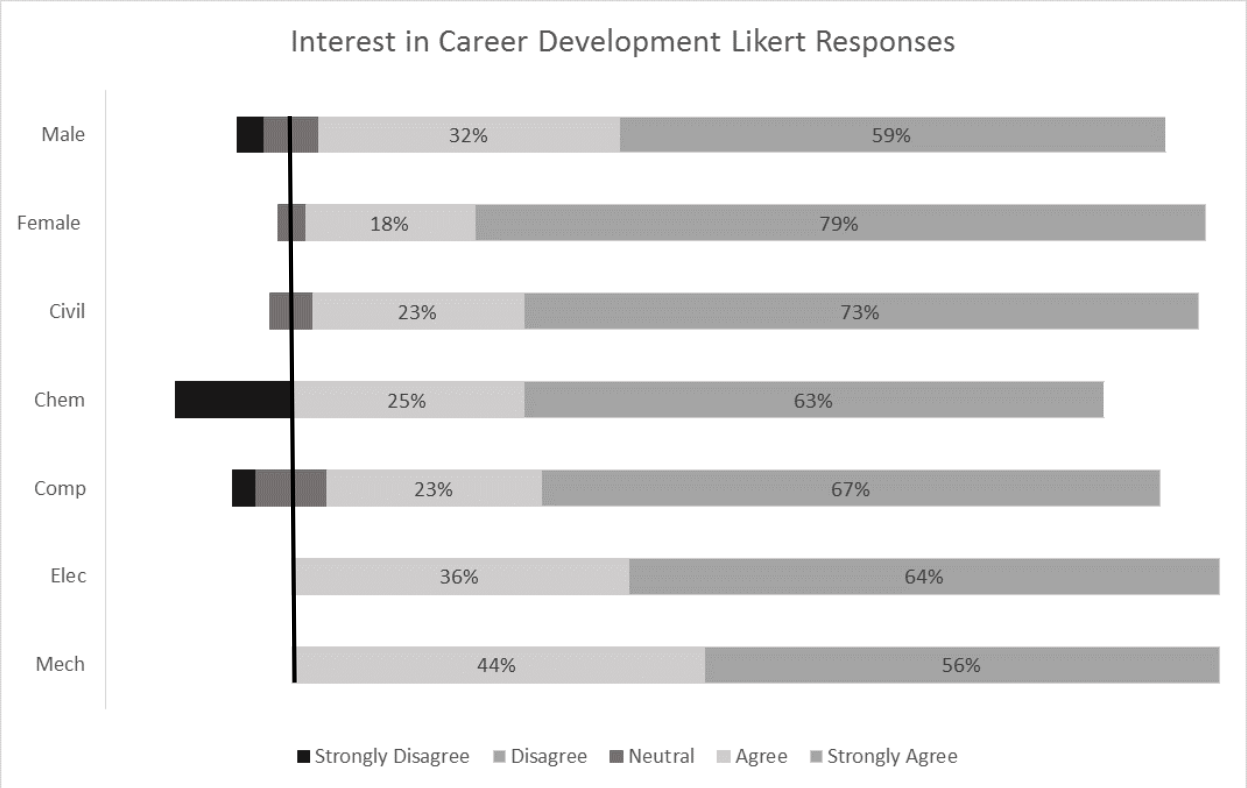

Figure 9: Frequency Chart of Percent Likert Responses for Career by Gender and Major

Conclusion and Recommendations

The data from this survey indicates that men and women do not differ based on one side of the altruistic spectrum, since differences are seen at both ends. Men and women also differ on the neutral topic of personal experience.

Analyzing the distribution of responses to the survey of all students currently enrolled in the introductory engineering courses reveal how gender responses differ. These results can be used to address curriculum revisions, both within the multidisciplinary and discipline-specific introductory courses as well as the required and elective course offerings on a departmental level. Specific strategies for engaging women can be addressed through the findings of this study.

Summary of Results

- **Women are more likely to be motivated to major in engineering by the opportunity to have an impact on society.**
- **Women are less likely to be motivated to major in engineering by previous personal experience.**
- **Women are more likely to be motivated to major in engineering for career opportunities.**

The results of the statistical comparison indicate that there are a few curricular changes that can be improved or sustained to engage women. By providing students with projects that focus on helping society, the goals will more closely align with motivators for women in engineering. It is also important for K-12 programs that focus on STEM to recruit more women to give them more personal experience with engineering. Introductory engineering courses will also help encourage women by addressing career development. These changes can help to engage women in engineering and will hopefully help to retain them in their first years in the major.

The results presented in this paper are based on a relatively small sample size. Some data were not analyzed at the discipline level because that would lead to subsets of data that are too small for statistical reliability. The authors plan to continue to use these methods with data collected by surveying students in the same two courses over the next several semesters, with slight procedural refinements based on lessons from this first effort.

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