FIRST YEAR ENGINEERING STUDENTS' PERCEPTIONS OF ENGINEERING

BY

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THESIS

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ABSTRACT

Engineering at the University of Illinois at Urbana Champaign has steadily drawn increasingly larger incoming classes of students. With a significant population and a diverse number of programs, these freshmen will be entering a unique engineering culture. This study sought to understand the perspectives and experiences of the students in regards to their engineering identity as they entered the university in the Fall of 2017, and after they had completed their first semester of engineering. Differences in perceptions among demographics such as gender, ethnicity, and the different engineering majors were also examined.

Two surveys were administered to a population of 1986 freshman engineers within the first month of their first and second semesters. The surveys contained questions pertaining to the students' perceived understanding of and confidence in engineering, as well as their reasons for pursuing engineering. Common perceptions of engineering qualities and responsibilities, as well as shifts in those perceptions, were also assessed. Results demonstrated that students across all majors were confident in their ability to succeed, but female students reported lower levels of confidence than male students, both when first entering the University and after their first semester of college. Within the various engineering majors and programs themselves, there were differences in satisfaction levels. Students who were not in their first choice major were less likely to agree with being happy in their field or intending to stay in their major. However, overall the participants rated themselves as having a good understanding of engineering and planning to stay within engineering as a realm. Descriptors for engineers that were most commonly selected included 'Practical' and 'Analytical' while less commonly selected were 'Artistic' and 'Kind'. While there were differences in levels of agreement on the impact of various experiences such as meeting with an academic advisor or failing a test, paper or project, the overall agreement on experience effects allowed for an understanding of the development of freshman engineering identity at the University of Illinois.

Dedicated to my sisters and Sisterhood Undivided

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Thank you to Alexandra for your support, encouragement, and patience! I am grateful to have had you as an advisor twice in a row; it's an honor to both have been in your first Senior Design group and be your first thesis student to graduate.

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Chapter 1: Introduction

1.1 Introduction

The University of Illinois has been a center for engineering innovation and academic success for over 150 years. At the time of this study, there are over 15 different engineering majors and several engineering programs available. While the overall enrollment of women and minority engineering students has increased over time, there are still significant differences in the demographic statistics between genders and ethnicities. The size of engineering departments varies as well, with the larger ones such as Computer Science or Mechanical Engineering having a greater breadth of concentrations and application areas. Smaller departments often have more concentrated areas of interest, such as the Nuclear Engineering and Chemical Engineering departments. The variety between majors and differences in student demographics creates a unique culture of engineering at the university.

1.2 Purpose Statement

The purpose of this study is to better understand the perceptions and experiences of engineering freshmen during their first year of study, as well as to examine the differences between the two semesters and across student demographics.

1.3 Research Questions

In seeking to understand first year engineering perceptions and how they differ between groups and over time, the following research questions were developed.

1. What perceptions of engineering do first year students have when they arrive at the University of Illinois?
2. What perceptions of engineering do first year students have after their first semester at the University of Illinois?
3. How do these perceptions differ amongst student majors, genders, and ethnicities?
4. How do these perceptions change from the beginning of the first semester to the beginning of the second semester?

Chapter 2: Literature Review

2.1 Engineering Students' Perceptions

Engineering education has grown in significance as the focus on engineering development and diversity grows. One of the key concerns within the realm of engineering education is that of the students' perceptions of engineering in regard to their own engineering identity and abilities. Both the initial attitudes of incoming engineering students and the perceptions of students who have attended engineering courses are valuable insights into what may be factors for success and retention.

Studies have shown that initial attitudes towards engineering abilities make a significant difference on students' performance, with poor initial attitudes being linked to attrition from engineering programs. In a study by M. Besterfield-Sacre in 1997, incoming engineering students were surveyed on their perceptions of engineering as a field, their own abilities as engineers, and their confidence in their success [1]. The performance and retention of the students were then tracked for the following three years and related back to their initial attitudes. Students who left engineering in good academic standing had significantly different attitudes about themselves and engineering compared to students who stayed in engineering, or who left in poor academic standing. The initial attitudes of students who left in good standing reflected significantly lower general opinions of engineering courses and work, and lower confidence in their own knowledge and skills. This suggests that identifying initial attitudes such as low confidence and negative views of engineering and finding ways to improve them may lead to increased retention of students.

Another factor towards retention that is often considered alongside initial confidence levels and view of engineering is self-efficacy. Self-efficacy can be differentiated from self confidence in that it pertains to the belief in one's ability to attain a certain specified level of accomplishment. In a study by Dr. M. Hutchison-Green in 2006, first year engineering students were surveyed regarding their self-efficacy beliefs and what factors were related to them [2]. It was found that self-efficacy was largely shaped by mastery and vicarious experiences, in which either the subjects themselves mastered a task or encountered someone else mastering a task. The beliefs were also shaped by social persuasions, where interactions with teammates, professors, and teaching assistants could all influence how a student viewed their abilities [3].

2.2 Engineering Students' Experiences

Clearly, the experiences that students have play a role in what their perceptions will be. It is generally understood by the engineering education community that the first year of engineering is the most important in terms of the shaping of student perceptions. In [4] the authors observed relationships between persistence in first year students and retention in engineering, and based on their observations emphasized the importance of structured engineering experiences in the first year. Studies examining the shift of perceptions over the first year found that students in programs with hands-on applications and specialized engineering experiences grew to have a more positive view of engineering than those with broader curriculum based in just math and science introductory courses [5].

Experiences that have been commonly examined among first year engineering students include meeting with professors and teaching assistants, finding a mentor or advisor, joining student organizations, and failing an exam or project [6]. A specific study by R. Korte and K. Smith found that for negative experiences led to negative perceptions about engineering while positive experiences reinforced positive perceptions [7]. Joining student organizations ended up being a positive experience for every student who participated in the study, suggesting that one of the most important experiences for engineering students to have is joining groups. It should be noted, however, that the extent of the impact of these experiences often differs among students, depending on their course of study, gender, and ethnicity.

2.3 Differences in Perceptions and Experiences among Demographics

Historically, engineering has been a field predominantly filled with men. This has shaped a lot of public perception of engineering as a male space and field, and can lead to women in engineering having very different perceptions than their male counterparts. Research has consistently shown that female engineering students entering college often have lower confidence in their background knowledge of engineering and ability to succeed than their male peers [7][8][9]. The lower confidence levels in female engineering students has been a concern for many educators and researchers looking to increase retention rates in science and engineering fields. In a longitudinal study tracking women engineering students over 6 years, it was found that in the first year of engineering there was often a significant drop in academic self-confidence [8]. This

implies that women in engineering not only start off with lower confidence, but can decrease further over the course of the crucial first year depending on experiences. Factors that helped combat this noted confidence decrease were experiences in programs specifically meant for women in STEM, and membership in student groups within the university. Interestingly, when students were interviewed about their experiences during their first year and asked to rate their own confidence in their success, male students rated themselves much higher than female students, and cited feeling more accomplished than their peers as a reason for the confidence [3][7]. Female students, instead, felt inferior to their peers and thus gave lower ratings for themselves. Both groups of students were in fact similarly performing, showing that the difference in perceptions may be based more on social conditioning than factual evidence.

Other differences in perceptions have been noted in studies assessing attitudes of students in different specialties, and of different nationalities. In a 2003 study on engineering perceptions of students in 11 different engineering majors, it was found that students held higher regard for their own major, and that students in smaller, more selective programs saw engineering as a more competitive and male oriented field [10]. A similar study examining perceptions of domestic versus international students found that domestic students were more confident in their understanding and ability to succeed in engineering [11]. These differences show that the effects of experiences on perceptions of first year students cannot be considered monolithic.

2.4 Surveys on Student Populations

The anonymous nature and relatively low amount of time needed for completion of a survey makes it an appealing choice for most studies on subjects' perceptions. However, due to the increasing data-filled world students are navigating, increasingly researchers are seeing a decline in response rates to surveys of populations [12]. This is often referred to as survey fatigue, where participant refusal to complete multiple surveys leads to decreased responses. A study by K. Fosnacht et al. found that a response rate of at least 10% of the study population yielded over 80% similarity to responses from the entire population, and response rates over 20% yielded over 90% similarity [13]. For the purpose of this paper, response rates over 10% will be considered significant enough to draw conclusions about the overall engineering freshman population.

Chapter 3: Methodology

3.1 Aims of Study

Given the importance of the first year students' attitudes in determining a student's success, this study primarily aimed to understand the perspectives of incoming engineering students. The goal was to examine what perceptions students have when they arrive to the university and to engineering as a major, and then to examine those perceptions again after the first semester of college has been completed. A secondary aim was to further assess what significant differences in perceptions and attitudes exist in between student demographics such as ethnicity, gender, and major.

3.2 Online Survey

An anonymous online survey administered during the first month of each term was determined to be the most effective way to reach participants and achieve the study goals. The surveys were developed through informal focus groups[1] held with engineering students, reflecting on their perspectives and experiences when they were in their first years. Experiences or descriptors mentioned by multiple individuals were included in the surveys.

The surveys were designed to take an average of 5 minutes to finish, in order to have a significant number of participants fully complete all questions. Subjects were first asked to self-identify their ethnicities, genders, and majors. Each demographic question included both a "Prefer not to answer" and an "Other" option, with "Other" allowing participants to expand upon their answer if they chose. In questions which asked students to rate their responses, the scale included "Strongly Disagree", "Disagree", "Neutral", "Agree" and "Strongly Agree" which corresponded to numerical ranks of 1-5.[2]

[1] The focus group worksheet is included in Appendix B.

[2] All questions (except for the first three assessing demographics) for the first survey are included in Appendix E, while the questions for the second survey are included in Appendix H.

The surveyed population included all students entering the University in either the Engineering College or engineering programs such as Preengineering, which in the Fall of 2017 was a total of 1986 students. These students were sent a recruitment email (Appendices C and F) for the study within the first month of each semester, including information on the purpose of the research and a link to the survey. A reminder email containing the same information was sent to the same list of freshmen one week after the initial email, in order to encourage higher participation. Additionally, Engineering Learning Assistants (ELAs) who are upperclassmen assigned to first years within their major were asked to instruct their groups of freshmen to check their email and take the survey.

3.3 Analysis

In determining significant differences in responses between demographics, two different regression methods were used for the different types of questions. For questions of the form "Select all that apply" a simple logistic regression model was fit to the data, treating the response of each option as a binary (either Yes or No). For questions requesting a rating of agreement, an ordinal logistic model was fit, evaluating the different ratings as responses. Each of these methods evaluated significance of ethnicity, gender, and/or major at a 95% confidence level.

3.4 Institutional Review Board

The researcher completed the following courses in the Collaborative Institutional Training Initiative (CITI) program: Defining Research with Human Subjects, Informed Consent, Privacy and Confidentiality, Social and Behavioral Research, and Students in Research. The Institutional Review Board (IRB) approved all research procedures and study measures (Appendix A).

Prior to taking either online survey, students were asked to consent to the study through the first page of the survey. The consent forms for the first and second survey are included in Appendices D and G. Confidentiality was maintained by keeping participants IP address anonymous using SurveyMonkey for study administration. Participants were informed that the information gained through the surveys would be used as part of the researcher's thesis and could potentially be published in a journal or presented at a conference.

Chapter 4: Results

4.1 First Semester Survey Results

Of the 1986 surveys sent out to Engineering and Pre-Engineering freshmen, 462 were completed and included in the results, giving a response rate of 23.3%. The demographic statistics of the responses are shown in Figures 1, 2 and 3a.

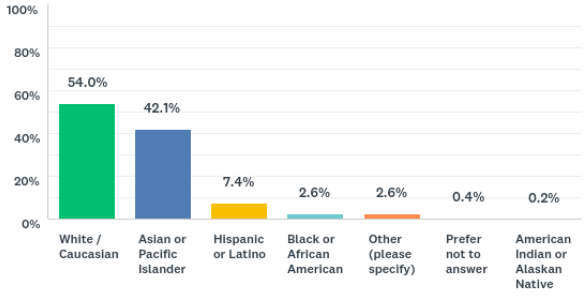

Figure 1: Ethnicity Statistics of Sample

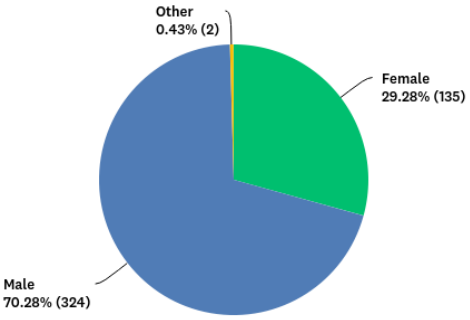

Figure 2: Gender Statistics of Sample

It can be seen that the majority of participants were either White or Asian/Pacific Islander, and 70.3% of participants were male. This does reflect the known demographics of the engineering population at the University, and follows trends noticed in engineering populations overall.

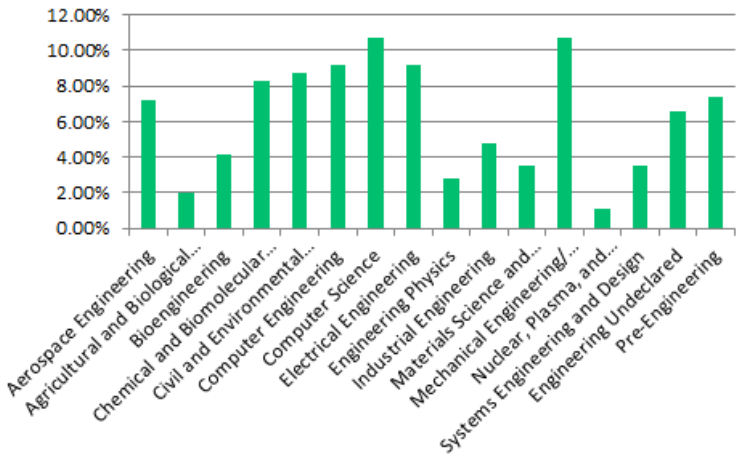

Figure 3a: Major Statistics of Sample

There were responses from every engineering major and engineering program available at the university, with the larger response groups corresponding to the larger programs (Electrical and Computer Engineering, Computer Science, Mechanical Engineering). This accurately reflects the distribution of students among these programs for the engineering population at the university, which can be seen in Figure 3b. These statistics for Figure 3b were drawn directly from the Fall 2017 official enrollment reports from the university [14]. The only difference in population percentages can be seen in the response rates from students in Engineering Undeclared and Pre-Engineering. There is a larger percentage of participants who enrolled in those programs, compared to the overall number of engineering freshmen at the university in those areas. This larger response rate can perhaps be attributed to those students not yet being in their set engineering major, and thus being more interested in giving feedback to the Engineering College and/or having stronger opinions about their perceptions and experiences thus far.

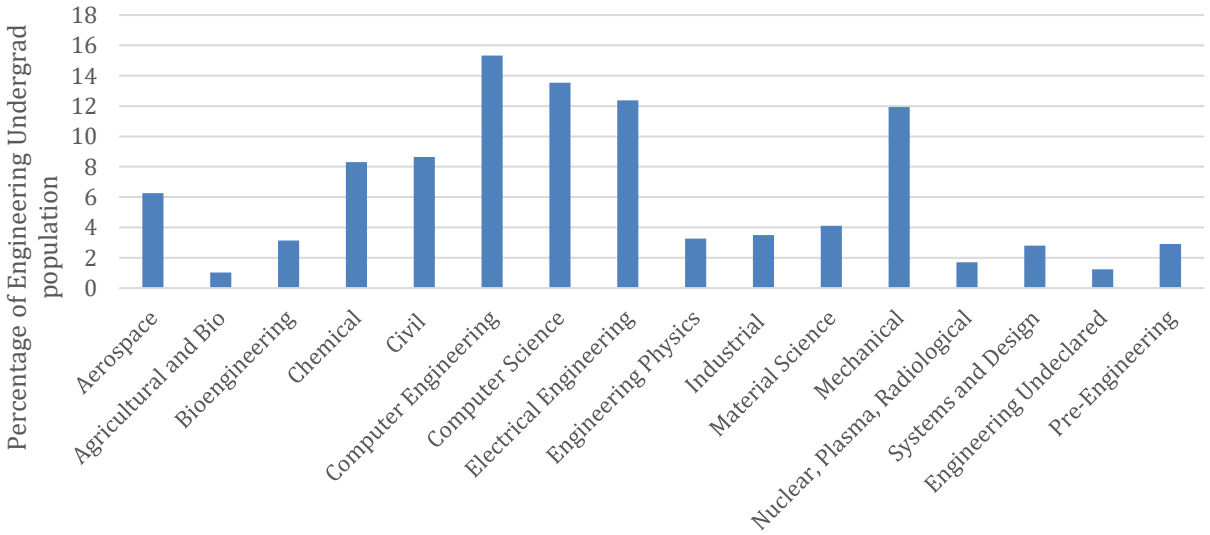

Figure 3b: Percentages of the Engineering Undergraduate Population which are in each Engineering Major.

In examining the students' choices of major, it was determined that gender and the major itself both made for differences in whether a student was in their first choice major or not. Table 1 shows how female students were over 11% more likely to be in their first choice major. The gender difference may be explained by the Engineering College initiative to include more women in engineering, as mentioned previously. By working to allow women into their first choice of major, the college can support more women in their engineering area of interest and avoid having them leave engineering as a field.

Table 1: Gender Differences in Choice of Major

My Major was my….		
	First Choice	Second Choice
Female	88.89%	5.93%
Male	77.09%	13.00%

Table 2 displays the difference in choice selection between the engineering majors. This difference is likely due to the acceptance rates and natures of the majors themselves, with the smaller and more selective majors (Materials Science, Nuclear, Agricultural) taking only students who would by nature have the major as their first choice. Larger majors also tend to have high amounts of students who selected them as their first choice, due to having the capacity to take many students. These majors also tend to be more highly ranked nationally and have more diverse job opportunities. It is the medium-sized majors whose placement process often takes students who didn't place into other majors (Systems and Engineering Design, Physics, Engineering Undeclared) who have the lowest number of students who chose the major as their first choice. Systems Engineering and Design in particular has equal number of students who selected it as their first and their second choice, likely due to the program's past as a General Engineering major.

Table 2: Major Differences in Choice of Major

My major was my....		
	First Choice	Second Choice
Q3: Aerospace Engineering	87.88%	12.12%
Q3: Agricultural and Biological Engineering	100.00%	0.00%
Q3: Chemical and Biomolecular Engineering	86.84%	13.16%
Q3: Civil and Environmental Engineering	92.50%	7.50%
Q3: Computer Engineering	95.24%	4.76%
Q3: Computer Science	97.96%	0.00%
Q3: Electrical Engineering	78.57%	21.43%
Q3: Engineering Physics	61.54%	38.46%
Q3: Industrial Engineering	81.82%	13.64%
Q3: Materials Science and Engineering	100.00%	0.00%
Q3: Mechanical Engineering/ Engineering Mechanics	93.88%	2.04%
Q3: Nuclear, Plasma, and Radiological Engineering	100.00%	0.00%
Q3: Systems Engineering and Design	43.75%	43.75%
Q3: Engineering Undeclared	62.96%	14.81%
Total	86.28%	10.72%

The next section of the survey asked questions assessing how students would rate their own understanding of engineering in various contexts. There was no significant difference in responses among the various demographics, and thus the average responses from the entire sample population are shown in Figure 4.

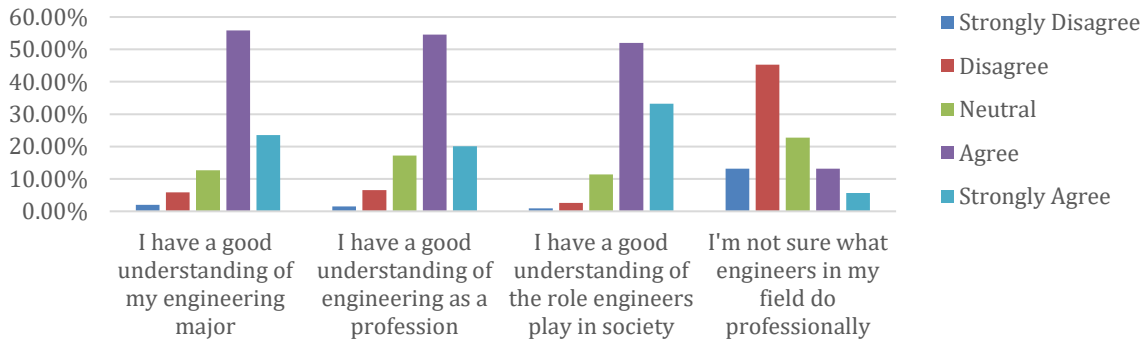

Figure 4: Participants Overall Rated Understanding of Engineering

Overall, incoming students rated themselves as having a good understanding of engineering both at the academic and professional level. However, the majority favored merely agreeing with their understanding being good, rather than strongly agreeing. In response to the question assessing whether they were unsure about the role of engineers in their field, the subjects primarily disagreed or chose to be neutral.

The next series of questions sought to further assess the confidence of the first-year students with regards to their own performance and success within engineering. Within the responses given by the subjects, significant differences were found between the male and female averages. These averages are given in Table 3, along with the calculated p-values denoting the strength of the statistical difference between the answers given by the two groups.

Table 3: Female vs Male Rated Confidence Responses, with P-Values

	Weighted Average		P-Value (< 0.05 highlighted)
	Female	Male	
I feel confident in approaching coursework in my major	3.41	3.82	8.68 e-05
I can get good grades in my classes	3.41	3.86	1.38 e-05
I will be successful in my field	3.71	4.00	3.41 e-03
I am just not good at engineering	2.34	2.19	0.099
Engineering is too difficult for me	2.36	2.07	0.013
I am good at math	3.71	4.02	6.70 e-05
I am good at science	3.67	4.16	2.37 e-09
Engineering is for students who are good at math and science	3.7	3.84	0.211

The entire group of participants on average rated themselves confident in their own abilities and had very similar agreement that engineering as a field is for students who are strong in math and science. Within each question however, males consistently rated themselves as agreeing more strongly with their own abilities and disagreeing more strongly with engineering being too difficult or not for them. Female participants tended to rate themselves closer to simply "Agreeing" or being "Neutral" when it came to their confidence in their success and abilities.

Satisfaction with their major was the next quality assessed in the survey, with a series of questions asking how much the subjects liked their current major and intended to stay with it. Figure 5a shows the overall average response to each question.

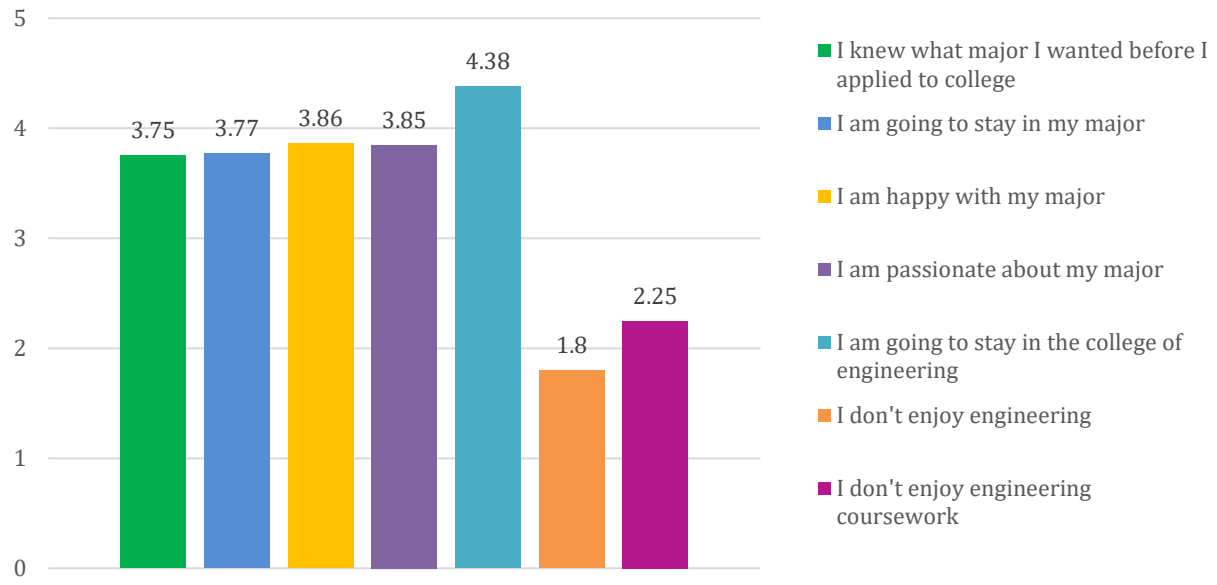

Figure 5a: Participant Responses to Interest in Major

On average, participants agreed that they were happy and passionate about their major and planned to stay with it and in engineering. Most students strongly disagreed (rating of 1.80) with the statement of not enjoying engineering but disagreed less strongly (rating of 2.25) about the statement of not enjoying engineering coursework. Students who expressed neutrality or disagreement about staying in their specific major still expressed strong agreement on the intention to stay within engineering.

Within the majors themselves, certain patterns of responses occurred for the various questions. The most statistically significant differences in responses occurred with the questions of being happy in their major and intending to stay in their major (with p-values of less than 0.0001). The programs with students least happy and least intending to stay were the same ones which had a higher percent of students who were not there as a first choice, such as Engineering Undeclared, Pre-Engineering, Engineering Physics, and Systems Engineering. This suggests that students who got into their first choice of program are therefore happier with their program and more likely to intend to stay in it. Additionally, the majors Engineering Undeclared and Pre-Engineering are by their nature not meant for students to remain in them for long. Figure 5b shows how the responses varied by major for the two questions.

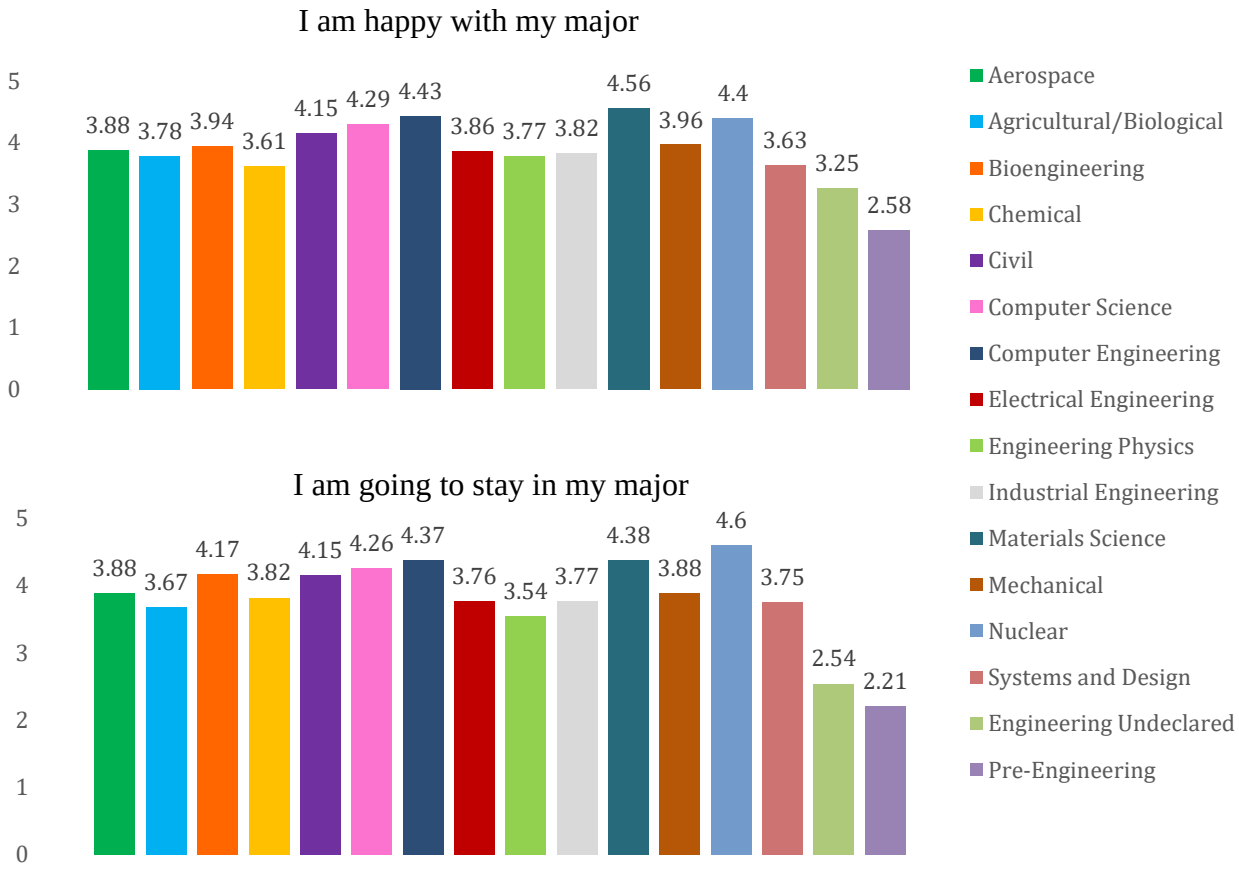

Figure 5b: Differences in Weighted Average Responses between Majors

One of the goals of the study included understanding why the incoming students chose engineering and their majors specifically. Question 8 on the survey asked which applicable experiences influenced the participants' decisions to apply for engineering at the university. Among the responses given by the participants, the only significant differences found were between male and female students. Due to the structure of the question, it is unknown whether non selection of an experience means it was not influential, or that it did not happen. However, comparing selection responses levels can yield the understanding of which experiences did have an influence when they occurred. Figure 6 shows the different response levels between genders to the various experiences.

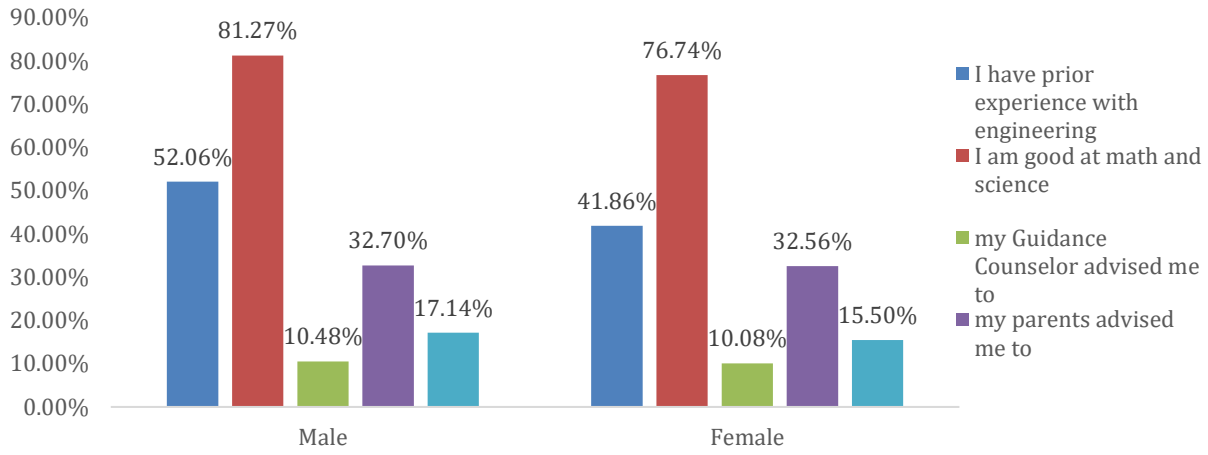

Figure 6: Male Participants and Female Participants Reasons for Choosing Engineering

The significant difference (with p-value 0.037) was in having prior experience in engineering, where only 41.9% of female participants attributed that as a factor for their choice of engineering, as compared to 52.1% of males. Being strong in math and science was the most commonly selected reason for choosing engineering, between all participants. Prior experience (at the different levels between genders) was the next most commonly selected, with parental advice being the third most commonly selected. Notably, guidance counselor advice was only chosen by about 10% of participants as a reason for pursuing engineering. This could mean not many incoming students received advice from their guidance counselors in regard to engineering, or if they did it was only influential for about 10% of the participants.

Figure 7a shows participant responses to a further list of reasons for choosing their major specifically. It is assumed that the participants responded in regards to their first choice major.

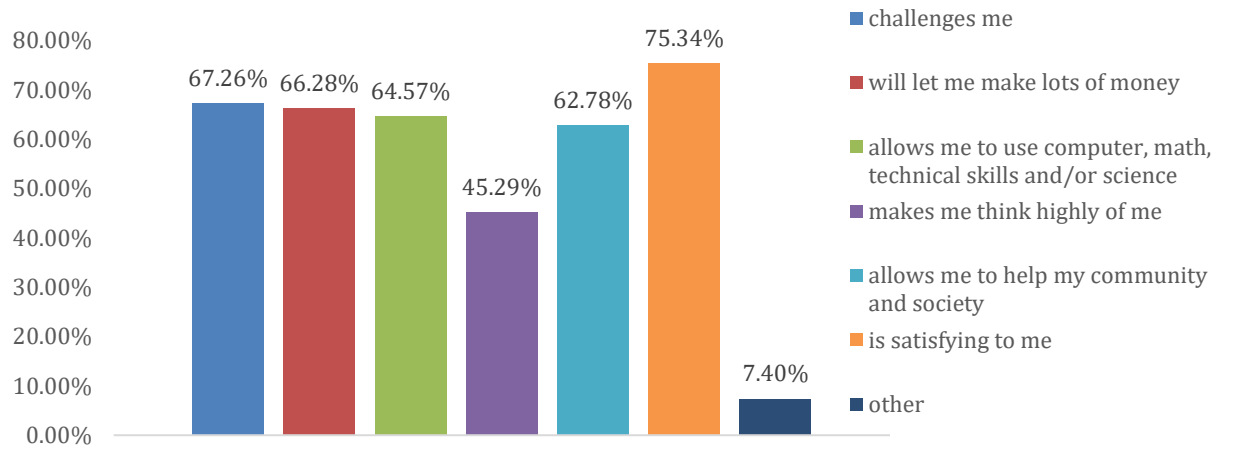

Figure 7a: This figure displays participant responses to a list of reasons for choosing their major

Most of the reasons given were selected by 60-70% of participants, including wanting work that "challenges", "makes money", "allows for use of technical skills", and "helps the community". The most selected reason (at 75.3% response) was that participants chose their major because they wanted work that was satisfying to them. The definition of what made work satisfying was not specified in the question, which may explain the slightly higher selection rate of the reasoning. A combination of the other reasons could also be potentially perceived as "satisfying".

Notably, the only reason that was selected by less than half the participants was that of choosing the major in order to have work which made the students think highly of themselves. Overall, this was only selected by 45.3% of subjects, but within the various majors of the subjects there were statistically significant differences (with a p-value of 0.0052). These differences are illustrated in Figure 7b.

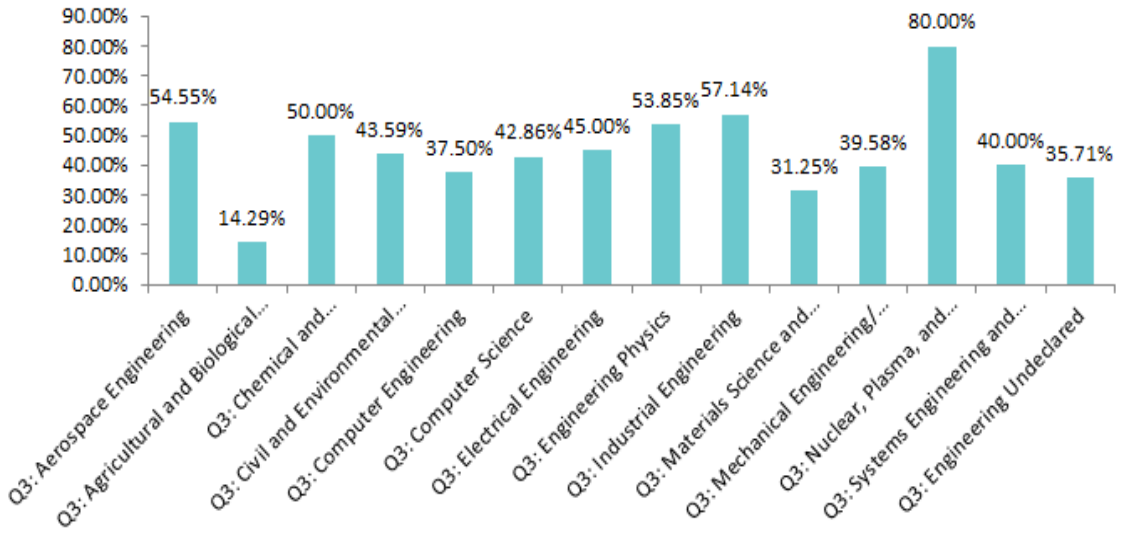

Figure 7b: Percentages of the different majors that chose major for work that makes them think highly of themselves

Freshman students in most majors had a selection rate of about 35-50% for the statement about thinking highly of themselves. The two significantly different major groups were Agricultural Engineering and Nuclear Engineering. Of the participants in Agriculture Engineering, only 14.3% chose wanting work that made them think highly of themselves as a reason for pursuing their major. By contrast, 80% of the Nuclear Engineering participants selected that same reason. This significant difference, along with the other selection percentage differences between the other majors, reflects the diversity in engineering identity between the different majors and corresponding engineering fields.

The survey continued by asking questions on what specific examples of work or characteristics participants pictured when contemplating engineers. Subjects were asked to rate how much they agreed with the examples of types of work engineers do. Within the ratings received in responses to these questions, the only statistically significant differences were between genders. Table 4 shows the average weighted responses on the scale from 1 to 5 from both main gender groups, along with the calculated p-values.

Table 4: Perceptions of What Engineers Do (Female vs Male)

Please rate the extent to which the following statements agree with your idea of what engineers do (Scale of 1 to 5)	Weighted Average		P Value (< 0.05 highlighted)
	Female	**Male**	
Mainly work on machines and computers	3.32	3.45	0.029
Mainly work with other people to solve problems	4.26	4.19	0.298
Work on things that help the world	4.43	4.29	0.031
Work on designing and improving	4.49	4.39	0.092
I don't know what engineers do	1.8	1.84	0.913

On average, all participants strongly agreed that engineers worked with other people, to help the world, and to design and improve things. Also, participants disagreed with the statement that they did not know what engineers did. However, within the responses, female participants agreed significantly less strongly that engineers worked mainly on machines and computers, and agreed more strongly that they work to help the world, when compared to the male participants. This suggests a gendered difference in perception of engineering responsibility.

The final question of the survey asked for participants to select any descriptors that matched with their idea of an engineer. Figure 8 shows the ranking of the characteristics in terms of how commonly selected they were by participants, with no significant differences in selection among demographics. Adjectives generally viewed as negative (such as "Loner" or "Unimaginative") were the least selected, with response rates in the range of 3-10%. The next least selected descriptors are "Kind" and "Artistic", which are non-negative but were only chosen by 33% and 25% of participants respectively. The most commonly selected descriptors are "Analytical" and "Practical", each chosen by about 88% of participants. The range of descriptors selected by over a majority of participants also include "Competitive", "Big Picture Oriented", "Confident", "Helpful", "Understanding", and "Thrive Under Pressure". This list allows an understanding of the common perception of engineers among the first year students as they began their studies.

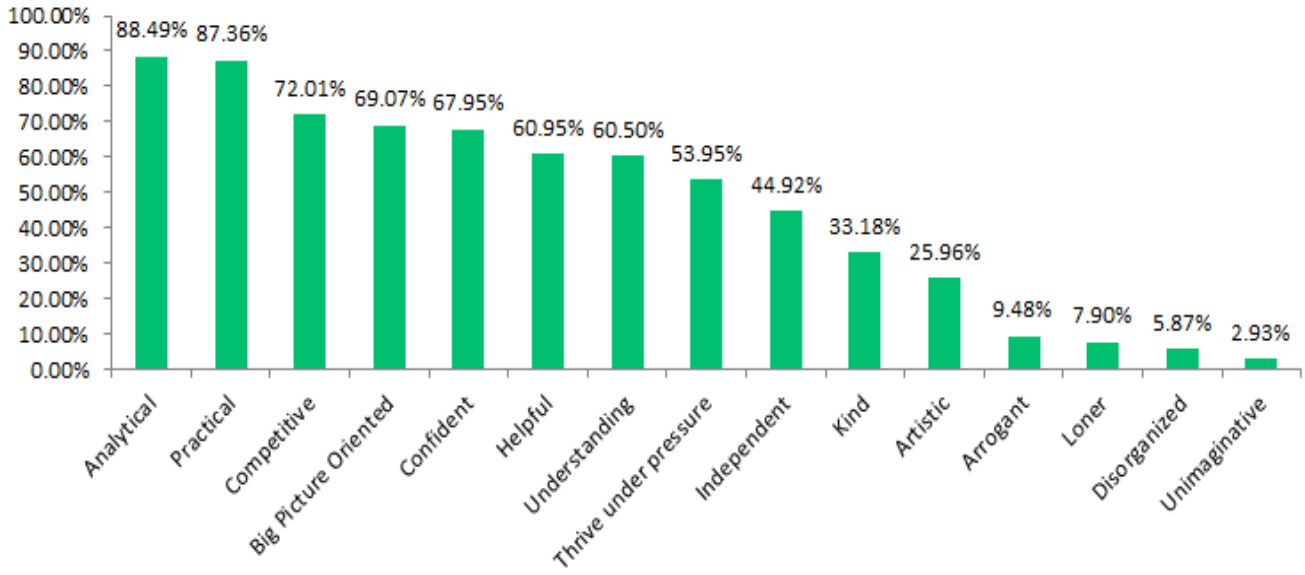

Figure 8: Percentage of Participants Who Selected Various Characteristic for Engineers

4.2 Second Semester Survey Results

Of the 1986 surveys sent out to Engineering and Pre-Engineering freshmen in the beginning of the Spring 2018 semester, 282 were completed and included in the results, giving a response rate of 14.2%. This response rate was notably lower than the rate from the first survey. A potential reason for this lower response rate is survey fatigue, the phenomenon where an overexposure to the survey process can lead to nonresponse as referenced in the literature review [12]. After a full semester at the University, freshman students may have been overexposed to surveys and emails from their departments, organizations, and classes. A response rate of 14.2% was still considered high enough to allow for reasonable conclusions about the overall population.

The demographic statistics of the responses are shown on the following page in Figures 9, 10 and 11. The similarity in response statistics between the first and second surveys allows for meaningful comparison between the two.

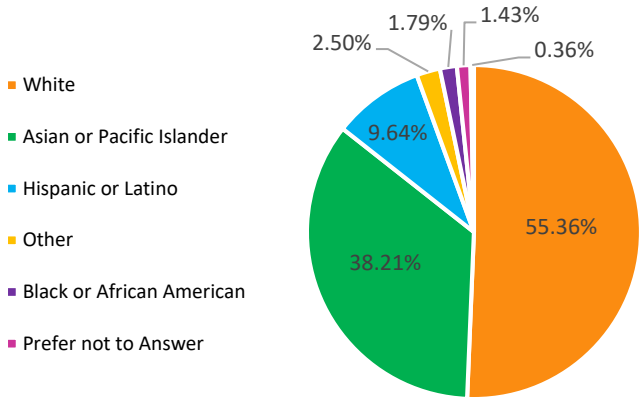

Figure 9: Ethnicity Statistics

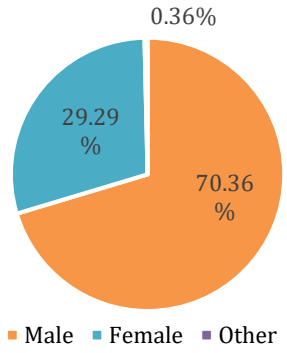

Figure 10: Gender Statistics

It can be seen that the majority of participants for the second survey were either White or Asian/Pacific Islander, and 70.36% of participants were male. These numbers match the respective percentages from the first survey, and therefore the overall population trends of engineers at the University of Illinois.

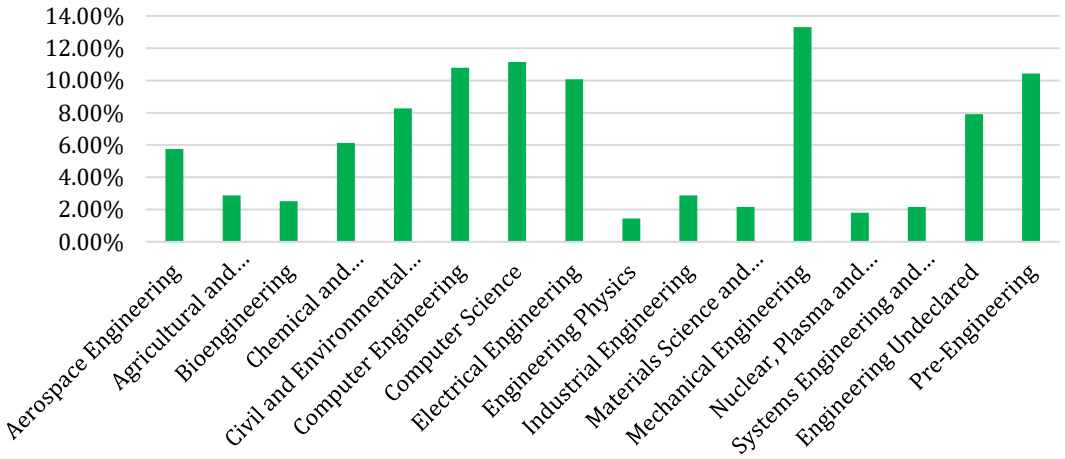

Figure 11: Sample Major Statistics

Once again there were participants from every engineering major and program on campus, with the distribution of responses following the population distribution of majors with the exception of Engineering Undeclared and Pre-Engineering. Both programs had disproportionately high response rates, indicating that students in those programs were more inclined to give feedback on their experiences in Engineering at the University. This followed the trend noted in the first survey responses.

Table 5: Major Differences in Choice of Major

My major was my....		
	First Choice	Second Choice
Q3: Aerospace Engineering	87.50%	12.50%
Q3: Agricultural and Biological Engineering	87.50%	12.50%
Q3: Chemical and Biomolecular Engineering	82.35%	17.65%
Q3: Civil and Environmental Engineering	86.96%	13.04%
Q3: Computer Engineering	96.67%	3.33%
Q3: Computer Science	100.00%	0.00%
Q3: Electrical Engineering	85.71%	10.71%
Q3: Engineering Physics	75.00%	25.00%
Q3: Industrial Engineering	87.50%	12.50%
Q3: Materials Science and Engineering	100.00%	0.00%
Q3: Mechanical Engineering/ Engineering Mechanics	97.30%	0.00%
Q3: Nuclear, Plasma, and Radiological Engineering	100.00%	0.00%
Q3: Systems Engineering and Design	66.67%	0.00%
Q3: Engineering Undeclared	63.64%	9.09%
Q3: Bioengineering	100.00%	0.00%
Q3: Pre-Engineering	3.70%	33.33%

Table 6: Gender Differences in Choice of Major

My Major was my….		
	First Choice	Second Choice
Female	85.19%	4.94%
Male	78.68%	11.17%

Tables 5 and 6 above show the differences between majors and genders in whether participants were in their first or second choice major. Systems Engineering, Engineering Undeclared, and Pre-Engineering all had sizable portions of responses where the participants did not even choose to be in their major. Additionally, more female students in this sample were in their first choice major than male students. These numbers match the differences seen in the sample of students in the first survey in the fall.

The next question assessed how students rated their own understanding of engineering in various contexts. The average responses from the entire sample population are shown in Figure 12.

Figure 12: Participants Overall Rated Understanding of Engineering

Participants rated themselves as mostly agreeing or strongly agreeing with their understanding of engineering being good. The majority of participants also disagreed that they did not know what engineers did in their field. Overall, participants agreed most strongly with their understanding of engineering roles in society. However, there were statistically significant differences (with p-values of 0.049 and 0.048 respectively) in responses between genders for the first and last statements. Charts of the different responses from female and male students for those two statements are shown in Figure 13.

While both female and male students overall rated themselves as having a good understanding of their major, almost 20% more female participants assessed themselves as "Neutral" as compared to male participants, who assessed themselves about 15% more as "Agree". This shows the same pattern of female students rating their understanding lower than their male counterparts as was seen in the first survey sent in the fall. Notably, 5% more male students did assess themselves as either "Disagree" or "Strongly Disagree", showing a portion of male participants did rank their understanding lower than the female participants.

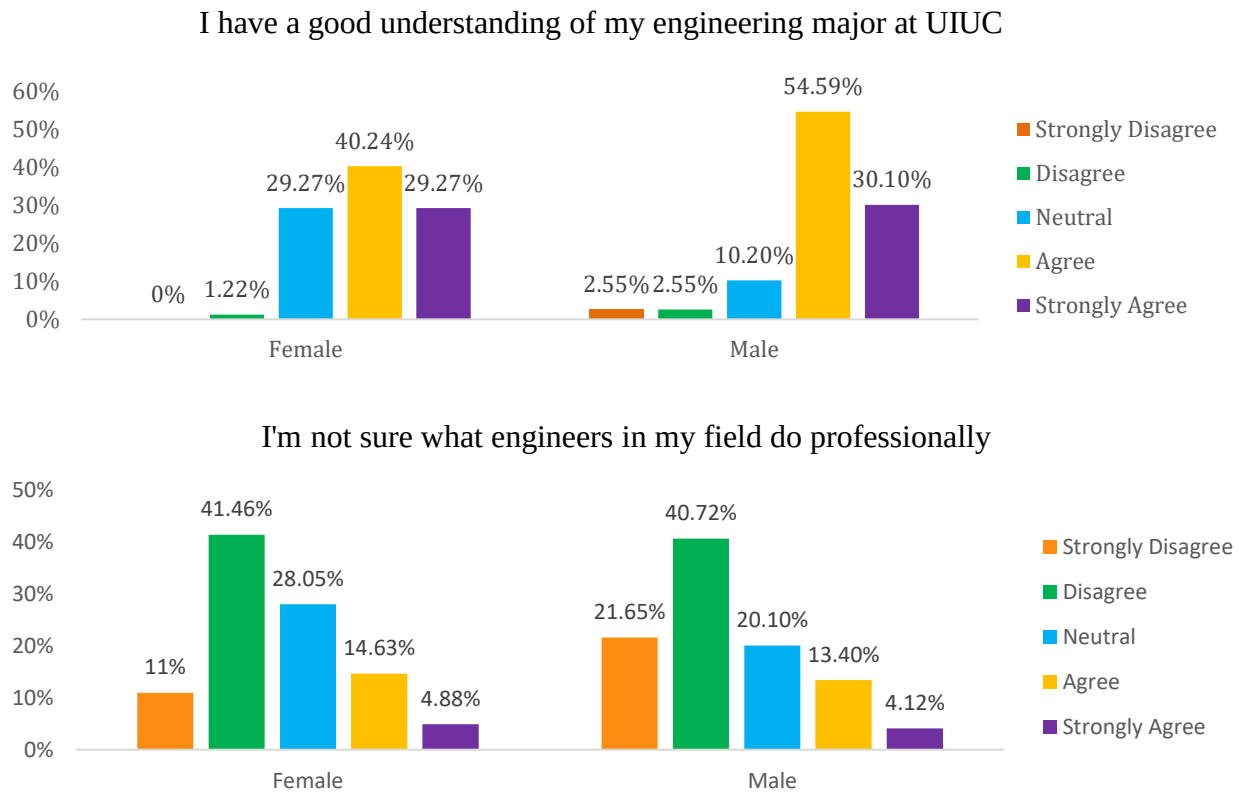

Figure 13: Male and Female Participants Rated Understanding of Engineering

In response to the statement regarding lack of understanding of what engineers do professionally in the respective students' fields, similar percentages of male and female students chose to either disagree (strongly or not) or be neutral. However, within those choices over 10% more male participants chose to "Strongly Disagree", while 8% more female participants chose to be "Neutral". This is another instance of female subjects being either less confident in their own understanding or less willing to take a strong stance on their understanding, as compared to the male subjects.

The next series of questions sought to understand the confidence of the students with regards to their own performance and success within engineering. Once again there were significant differences found between the male and female averages responses. These averages are given in Table 7, along with the calculated p-values denoting the strength of the statistical difference between the answers given by the two groups.

Table 7: Female vs Male Rated Confidence Responses, with P-Values

	Weighted Average		P-Value (< 0.05 highlighted)
	Female	Male	
I feel confident in approaching coursework in my major	3.33	3.94	1.34 e-06
I can get good grades in my classes	3.57	4.03	2.1 e-04
I will be successful in my field	3.77	4.06	5.44 e-03
I am just not good at engineering	2.27	2.19	0.196
Engineering is too difficult for me	2.15	2.03	0.132
I am good at math	3.74	4.00	0.0204
I am good at science	3.74	4.06	3.12 e-03
Engineering is for students who are good at math and science	3.50	3.78	0.0235

In Table 7 it can be seen in that female participants rated themselves as significantly less confident in their success within the classroom and the field. Overall, however, both male and female participants did rate themselves as being confident in their abilities. Students disagreed similarly with the statements “Engineering is too difficult for me” and “I am just not good at Engineering”. Interestingly, female participants rated themselves significantly lower in being good at math and science than their male counterparts, but also significantly agreed less with the statement “Engineering is for students who are good at math and science”. This implies that while there is the difference in confidence levels among genders for technical skills, female students do not necessarily see that as a barrier to being engineers.

Satisfaction with their major was the next quality assessed in the survey, with a series of questions asking how much the subjects liked their current major and intended to stay with it. Figure 14 shows the overall average response to each question, with responses from students in temporary majors (Engineering Undeclared and Preengineering) shown separate from those in set majors.

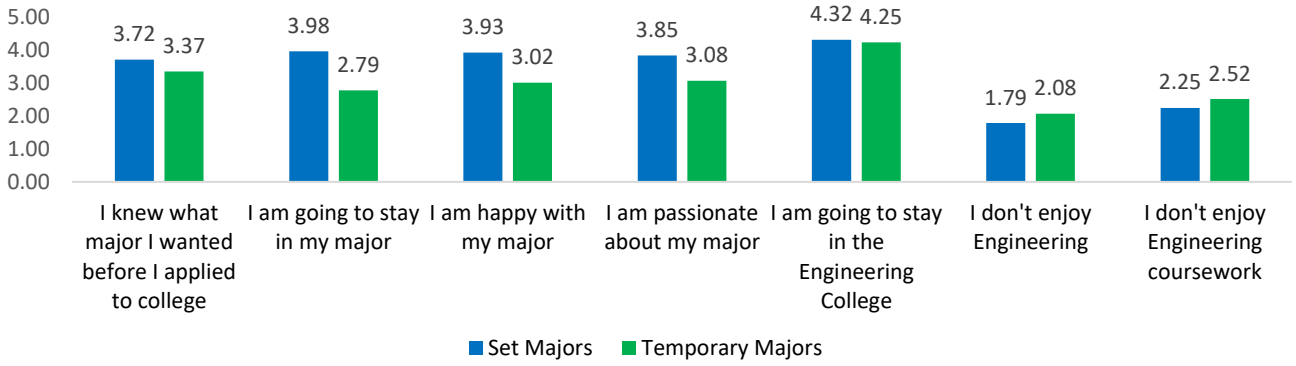

Figure 14: Satisfaction responses from Students in Set and Temporary Majors

It can be seen that students already in their set engineering majors overall rated themselves as enjoying their majors and planning to stay with them. While the temporary majors agreed significantly less with the statements about being happy with, passionate about, and staying in their current program (with p-values of less than 5e-6 each), they did respond similarly to wanting to stay in Engineering and disagreeing with not enjoying engineering or its coursework.

The next question assessed students' perceptions of what engineering work consisted of. This time, there were no significant differences in demographics among the responses, and thus the overall student answers are shown in Figure 15 below.

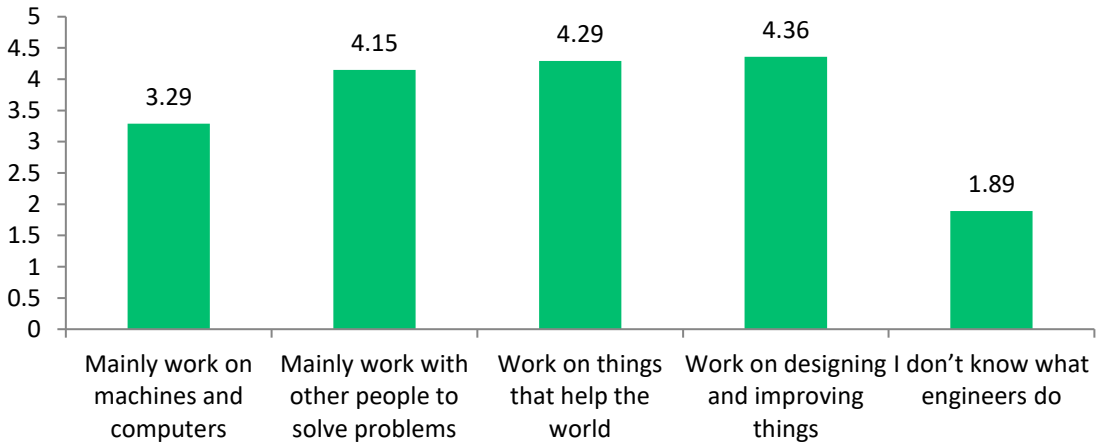

Figure 15: Perceptions of what Engineers Do

Participants agreed fairly strongly that engineers work to solve problems, help others, and design and improve things. Less strongly agreed with was the statement that engineers work mainly on machines and computers, showing that the students agreed that the purpose behind engineering was common, but the actual work done by engineers varies. Participants overall disagreed that they did not know what engineers did.

The second survey next asked students to reflect on their own changes in perception of themselves and engineering from the time when they took the first survey. There were statistically different responses between genders for the first question, regarding confidence in engineering success. The responses to the first question are shown in Table 8.

Table 8: Shifts of Confidence Compared Between Genders

Compared to when I first started this school year I feel more confident about my success in engineering	
Male	3.63
Female	3.33
P-Value	0.029

When assessing their own sense of confidence in engineering, male students agreed more strongly that they had increased in confidence compared to the past semester. Female students, while still rating themselves as agreeing to an increase, were closer to being “Neutral” than to “Agree”. This also reflects the difference in actual confidence levels between the genders shown in both the first and second survey. This reflects the trend noted in previous studies in the literature [9] where female engineering students consistently displayed lower self-confidence than their male peers.

The next question assessing shifts over the past semester asked students about their change in understanding of their major. Students in different majors had significantly different responses to this prompt, with a p-value of 0.0013. Figure 16 shows the level of agreement from the various majors that the students in them had gained a better understanding since the beginning of the year.

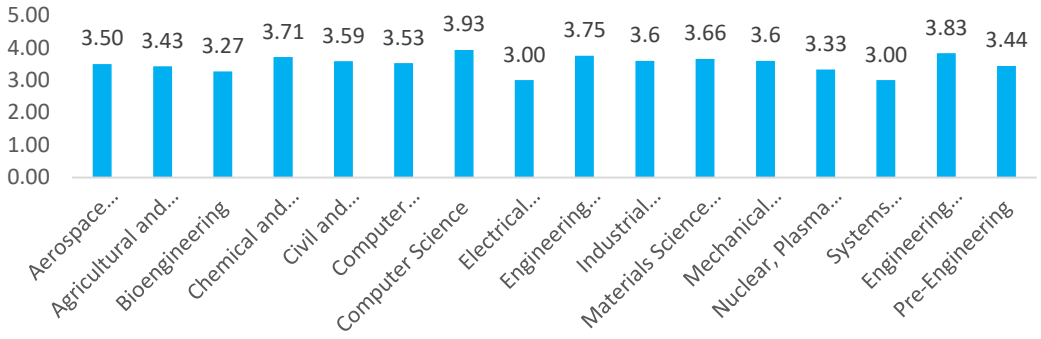

Figure 16: Compared to when I first started this school year I understand more about my engineering major

All but two majors had students who agreed they understood their major better since the time of the first survey. Those two majors were Electrical Engineering and Systems Engineering, which had students who overall rated themselves as "Neutral" on having increased understanding. The majors with the highest rated increase of understanding were Computer Engineering and Engineering Undeclared. These differences in student understanding among majors may come down to what classes and resources are offered in respective fields during the first semester of college.

The final question on self-assessed perception shifts focused on the understanding of engineering as a field. There were no significant differences in responses between demographics, and the distribution of answers is shown in Figure 17.

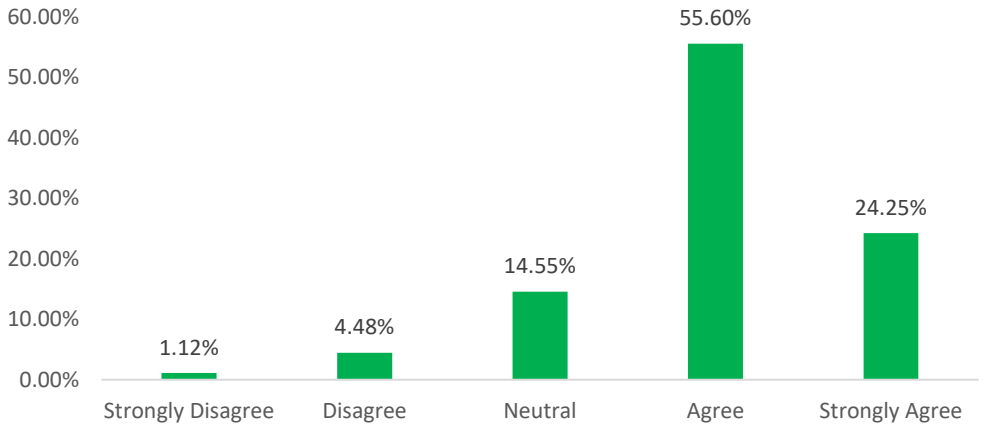

Figure 17: Compared to when I first started …. I understand engineering as a field more

Almost 80% of participants agreed that they understood engineering as a field more than when they first entered the University, with 24% of them strongly agreeing. This suggests that even though students in some majors did not feel they understood their majors any better, they did have a better understanding overall of engineering after their first semester.

Students were next asked to rate a series of experiences based on how they affected the student' perception of engineering. Within the responses, there was a significant difference in how experiences affected male and female students. These differences, with their associated p-values, are given in Table 9 below.

Table 9: Impact of Experiences on Students Perceptions of Engineering

Please indicate whether you believe the following experiences had positive (5) or negative (1) effects on your perception of engineering. If you feel neutral or did not have the experience, select (3).			
	Female	Male	P-Value (>0.05 highlighted)
Attended a Professor's Office hours	3.50	3.66	0.145
Attended a TA's office hours	3.83	3.73	0.406
Worked on a group project	3.47	3.64	0.335
Met with academic advisor	3.51	3.79	0.021
Joined engineering student organization	3.99	3.69	0.006
Joined non-engineering student organization	3.80	3.57	0.025
Failed a test, paper, or project	2.53	2.85	0.007
Attended a tutoring session	3.61	3.59	0.89
Found a mentor (official or unofficial)	3.58	3.41	0.087
Made a friend in my major	4.42	4.28	0.158

While all students rated every experience (except for failing a test, paper, or project) as having a positive effect on their perception of engineering, it can be seen that female students found joining student organizations on campus to have far more of a positive impact than male students did. Male students found meeting with academic advisors more positive than female students did and found the experience of failing less negative. All students agreed that the most positively impactful experience was making a friend within their major.

Finally, the second survey concluded by again asking students to select the characteristics that fit with their idea of an engineer. There were no statistically significant differences among the student demographics. Responses are shown in Figure 18.

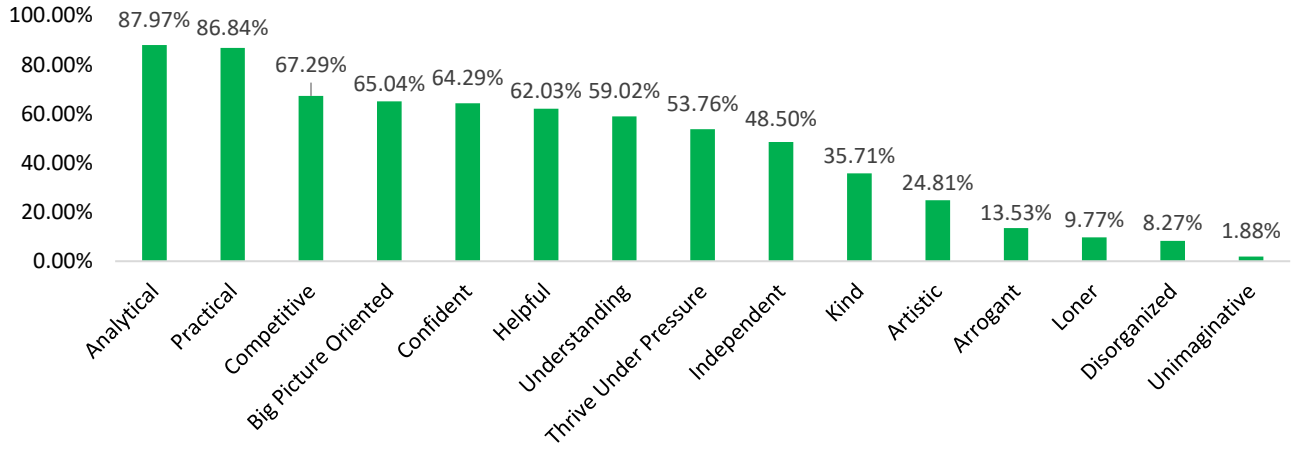

Figure 18: Percentage of Participants Who Selected Various Characteristic for Engineers

Once again, words with generally negative connotations were least selected. “Loner”, “Disorganized” and “Unimaginative” were all selected by under 10% of participants. The two most commonly selected were, as in the first survey, “Analytical” and “Practical”. The order of words chosen, from most selected to least selected, followed the exact same order as in the first survey. This would suggest that the descriptors that first year engineering students use to describe themselves or other engineers have not changed over their first semester of college.

Chapter 5: Discussion

5.1 Discussion of First Survey Results

From the first survey responses, several key observations can be made with regards to incoming engineering students perceptions. Mainly, first year students rated themselves as having a good understanding of what engineering is as a major and a field as they entered university. That understanding itself varied depending on what type of engineering program the first year student was in, and what gender they identified with. The majority of participants however saw engineering as cross functional, responding that engineers work with people, machines and technology to solve problems and help society. This multifaceted view is a positive sign for the freshmen engineers, as they will often have to work on projects and in areas that can span several engineering and non-engineering fields. Regardless of major, the first year students showed a grasp of the fundamentals of engineering being problem solving and improving.

Incoming engineering students also had largely positive perceptions of engineers as people, viewing them as practical, analytical, and helpful. Interestingly, the descriptors chosen most to describe engineers all pertained to how well they could perform their work as engineers and tended to reflect less on personal traits. While the participants self-identified engineers as competitive and confident, they were less inclined to also include descriptors such as kind or artistic. The overall positive perception of engineers is a good sign for retention of students.

As found in several previous studies, incoming female engineering freshmen tended to rate themselves lower in confidence in their success in engineering than their male peers. This difference in confidence perhaps reflects pressure women feel in engineering as a minority group, or follows the trends of women being less likely to rate themselves highly when compared to men. Given that the confidence rating they had was still positive, this initial attitude towards engineering is not necessarily cause for concern. The most common reasons students selected for pursuing engineering were their abilities in math and science, followed by having prior experience with engineering. However, female participants selected prior experiences as a reason at a significantly lower level than their male counterparts. This could either imply that they did not have prior experiences with engineering to the same extent the male students did, or that prior experiences

they had weren't significant reasons for why they chose engineering. The former explanation is more likely. Within the next five to ten years, however, the difference in experiences may be insignificant as programs with the purpose of introducing girls to STEM fields and practices expand. Increased exposure to engineering and earlier introduction to female engineering role models may also lead to increased initial confidence in women who decide to pursue engineering.

Students in majors which were either their second choice or a temporary option (such as Preengineering) tended to be less satisfied with their major, but still interested in and passionate about engineering. As these were their initial attitudes, it is possible that they could grow to like the major they were in or figure out a program they would want to try to transfer into. Overall, any negative initial attitudes were directed at their placement in programs, and not at themselves as engineers.

5.2 Discussion of Second Survey Results

The goal of the second survey was to notice and understand any shifts in the first year engineering students' perceptions. For the most part, students responded similarly as they had to the initial survey when they were new to the University. Some key differences could be seen in the self-reported understanding of engineering majors between male and female students. While both male and female students had similar overall weighted average ratings for the statements "I have a good understanding of my engineering major at UIUC" and "I'm not sure what engineers in my field do professionally", within their respective distributions female students were far more likely to be neutral, where male students were more likely to agree with having good understanding and disagree with being unsure. The previous survey had both genders responding with similar distributions of agreement. This could mean that over the first semester female students had experiences which made them doubt their understanding of engineering in their fields.

Continuing in the same vein, female participants once more ranked themselves as significantly less confident in their own success in engineering as compared to the male students. In fact, both male and female students responded less positively to statements concerning their own success as compared to the first survey, but had similar responses as before to the statements

about engineering being for those good at math and science. When asked to report for themselves how their confidence had shifted over the semester, students overall agreed that they felt more confident but once again female students agreed less strongly than male students.

In assessing how students' understanding of their majors had changed over the semester, it was found that different majors elicited different responses. Majors with first semester coursework that included direct engineering applications relevant to their specialization such as Computer Science or Engineering Undeclared had students with the highest reported increase in understanding. Electrical Engineering and Systems Engineering had students report no change in understanding of the major. This can likely be explained by the fact that neither major has engineering coursework for freshman students until later in the curriculum. Furthermore, Systems Engineering is a newer program that is still being developed. However, regardless of their understanding of their specific majors, overall students agreed that their understanding of engineering as a field had increased.

The final thing to examine is what experiences students reported as positive and negative in how they affected their perceptions of engineering. These are the experiences which may explain female students losing confidence in their understanding, and students both increasing and decreasing in confidence of their success. Overall, students agreed that making a friend in their major was the most positive experience they had, with female students reporting joining student organizations (engineering or otherwise) as the next most positive. This suggests that having a community and potential support system of people played a large role in female students feeling more positive about engineering. Perhaps joining groups and making friends counteracts feelings of being out of place or less successful than male peers. Male students, on the other hand, found meeting with academic advisors more positive than female students did, and found failing a paper or test to be less negative. As the majority of faculty within the College of Engineering are male, the difference in experiences could be explained by female students not relating with their advisors and vice versa. The difference in response to failure indicates that male students had slightly more persistence attributes, which corresponds to previous studies in the literature.

5.3 Limitations of Study

Due to the nature of the survey, students who chose to respond may have introduced a degree of participation bias. Those who had a strong enough opinion to want to fill out a survey on their experiences may have stronger opinions than the majority of the student population. The existence of a significant number of responses which stayed around neutral, however, indicates this potential bias may not be present.

The numbers of students who participated in the study who were neither White nor Asian (the two groups consisting of the vast majority of the population) were small enough that it was not possible to draw any statistical significance from differences in responses. Thus, ethnicity was never found as a statistically significant factor on any of the questions. This does not mean ethnicity does not play a role in how students experience and perceive engineering, but the scope of this study was unable to pursue ethnicity effects further.

5.4 Conclusion

In conclusion, the first year engineering students at the University of Illinois already arrive with positive perceptions of engineering and confidence in their ability to succeed. Female students come in with significantly less confidence than their male counterparts but are still positive, and if they are able to make connections while at the university with other people both within and outside of engineering, their confidence will be able to grow. Students placed in majors outside of their first choice may harbor more negative attitudes towards that major, but still have shown to have positive attitudes towards engineering as a field and confidence in their ability to succeed. The first year of engineering at the university should ideally hold as many possibilities for freshmen students to experience engineering activities as possible, as it is those activities which allow for increased understanding and confidence among all students.

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APPENDIX A: IRB Approval Letter

IRB EXEMPT APPROVAL

RPI Name: Alexandra Chronopoulou
Project Title: Perception of first year engineering experiences at the University of Illinois
IRB #: 17619
Approval Date: April 25, 2017

Thank you for submitting the completed IRB application form and related materials. Your application was reviewed by the UIUC Office for the Protection of Research Subjects (OPRS). OPRS has determined that the research activities described in this application meet the criteria for exemption at 45CFR46.101(b)(2). This message serves to supply OPRS approval for your IRB application.

Please contact OPRS if you plan to modify your project (change procedures, populations, consent letters, etc.). Otherwise you may conduct the human subjects research as approved for a period of five years. Exempt protocols will be closed and archived at the time of expiration. Researchers will be required to contact our office if the study will continue beyond five years.

Copies of the attached, date-stamped consent form(s) are to be used when obtaining informed consent. We appreciate your conscientious adherence to the requirements of human subjects research. If you have any questions about the IRB process, or if you need assistance at any time, please feel free to contact me at OPRS, or visit our website at http://oprs.research.illinois.edu

Sincerely,

Rebecca Miller, MSW
Human Subjects Research Specialist, Office for the Protection of Research Subjects

APPENDIX B: Informal Focus Group Worksheet for Survey Design

Major : _____
Year in college (ex:Freshman/First year) : _____

What perceptions of engineering did you have as a starting freshman? (roles engineers play, skills they should have, what they do, etc)

Perception after one semester of college……

Who or what influenced you to pursue engineering? At UIUC? In your major?

Negative experiences with engineering…

Positive experiences with engineering….

How have your experiences changed your perception of engineering? Has there been a perception shift?

APPENDIX C: Recruitment Email for Fall 2017 Online Survey

Hello,

My name is Marigold Bays-Muchmore and I am a graduate student in the Industrial and Enterprise Systems Engineering Department at the University of Illinois at Urbana Champaign.

I am currently conducting research and I need your help. The topic being studied is first year student perceptions of their engineering experiences at the University of Illinois. You have been selected for the chance to participate in this study because you have entered the University of Illinois in the fall of 2017 and begun your collegiate career in an Engineering major or program.

The following link will take you to an anonymous online survey which should take no more than 10 minutes to complete. On the survey you will be asked about your first year experiences and perceptions of engineering at the University of Illinois. Please proceed on to the survey only if you are 18+ years old.

(Link to survey here)

Thank you so much for considering taking the survey, and please contact me if you have any questions.

Thank you!

APPENDIX D: Informed Consent Form for First Online Survey

You are invited to participate in a research study on first year engineering student experiences. This study is conducted by Marigold Bays-Muchmore, a Masters student in the Industrial and Enterprise Systems Engineering Department at the University of Illinois Urbana Champaign.

This study will take approximately 4 minutes of your time. You will be asked to complete an online survey about your experiences and perceptions of engineering as a first year engineering student.

Your decision to participate or decline participation in this study is completely voluntary and you have the right to terminate your participation at any time without penalty. You may skip any questions you do not wish to answer. If you want do not wish to complete this survey just close your browser.

Although your participation in this research may not benefit you personally, it can help us understand how best to support and retain first year engineering students. There are no risks to individuals participating in this survey beyond those that exist in daily life. Your decision to participate, decline, or withdraw from participation will have no effect on your current status or future relations with the University of Illinois.

Faculty, students, and staff who may see your information will maintain confidentiality to the extent of laws and university policies. Personal identifiers will not be published or presented.

If you have questions about this project, you may contact Marigold Bays-Muchmore at baysmuc2@illinois.edu or (425) 749-0004.

If you have any questions about your rights as a participant in this study or any concerns or complaints, please contact the University of Illinois Office for the Protection of Research Subjects at 217-333-2670 or via email at irb@illinois.edu.

Please print a copy of this consent form for your records, if you so desire.

I have read and understand the above consent form, I certify that I am 18 years old or older and, by clicking the submit button to enter the survey, I indicate my willingness voluntarily take part in the study.

APPENDIX E: Fall 2017 Survey Questionnaire

Question 4	My major was my ____ choice ❑ First ❑ Second ❑ Third ❑ Other
Question 5	Please rate the extent to which you agree with the following statements: ❑ I have a good understanding of my engineering major ❑ I have a good understanding of engineering as a profession ❑ I have a good understanding of the role engineers play in society ❑ I'm not sure what engineers in my field do professionally
Question 6	Please rate the extent to which you agree with the following statements: ❑ I feel confident in approaching coursework in my major ❑ I can get good grades in my classes ❑ I will be successful in my field ❑ I am just not good at engineering ❑ Engineering is too difficult for me ❑ I am good at math ❑ I am good at science ❑ Engineering is for students who are good at math and science
Question 7	Please rate the extent to which you agree with the following statements: ❑ I knew what major I wanted before I applied to college ❑ I am going to stay in my major ❑ I am happy with my major ❑ I am passionate about my major ❑ I am going to stay in the Engineering College ❑ I don't enjoy engineering ❑ I don't enjoy engineering coursework
Question 8	I chose Engineering because.... (please select all that apply) ❑ I have prior experience with engineering ❑ I am good at math and science ❑ My Guidance Counselor advised me to ❑ My parents advised me to ❑ Other (please specify)

Question 9	I chose my major because I wanted work that.... (select all that apply) ❑ Challenges me ❑ Will let me make lots of money ❑ Allows me to use computer, math, technical skills and/or science ❑ Makes me think highly of me ❑ Allows me to help my community and society ❑ Is satisfying to me ❑ Other (please specify)
Question 10	Please rate the extent to which the following statements agree with your idea of what engineers do ❑ Mainly work on machines and computers ❑ Mainly work with other people to solve problems ❑ Work on things that help the world ❑ Work on designing and improving things ❑ I don't know what engineers do ❑ Other (please specify)
Question 11	Which of the following words agree with your idea of an engineer? Select all that apply. ❑ Confident ❑ Competitive ❑ Independent ❑ Big Picture Oriented ❑ Helpful ❑ Practical ❑ Kind ❑ Unimaginative ❑ Thrive under pressure ❑ Analytical ❑ Understanding ❑ Disorganized ❑ Loner ❑ Artistic ❑ Arrogant

APPENDIX F: Recruitment Email for Spring 2018 Online Survey

Hello,

My name is Marigold Bays-Muchmore and I am a graduate student in the Industrial and Enterprise Systems Engineering Department at the University of Illinois at Urbana Champaign.

I am currently conducting research and I need your help. The topic being studied is first year student perceptions of their engineering experiences at the University of Illinois. You have been selected for the chance to participate in this study because you have entered the University of Illinois in the fall of 2017 and begun your collegiate career in an Engineering major or program.

The following link will take you to an anonymous online survey which should take no more than 10 minutes to complete. This survey is a follow up to a survey sent in the fall semester. You do not need to have completed the first survey to fill this one out.

On the survey you will be asked about your first year experiences and perceptions of engineering at the University of Illinois over the last semester. Following the completion of the survey you will be informed about an opportunity to give additional feedback about your first year experience. **Please proceed on to the survey only if you are 18+ years old.**

(Link to survey here)

Thank you so much for considering taking the survey, and please contact me if you have any questions.

Thank you!

APPENDIX G: Informed Consent Form for Second Online Survey

You are invited to participate in a research study on first year engineering student experiences. This study is conducted by Marigold Bays-Muchmore, a Masters student in the Industrial and Enterprise Systems Engineering Department at the University of Illinois Urbana Champaign.

This study will take approximately 4 minutes of your time. You will be asked to complete an online survey about your experiences and perceptions of engineering as a first year engineering student.

Your decision to participate or decline participation in this study is completely voluntary and you have the right to terminate your participation at any time without penalty. You may skip any questions you do not wish to answer. If you want do not wish to complete this survey just close your browser.

Although your participation in this research may not benefit you personally, it can help us understand how best to support and retain first year engineering students. There are no risks to individuals participating in this survey beyond those that exist in daily life. Your decision to participate, decline, or withdraw from participation will have no effect on your current status or future relations with the University of Illinois.

Faculty, students, and staff who may see your information will maintain confidentiality to the extent of laws and university policies. Personal identifiers will not be published or presented.

If you have questions about this project, you may contact Marigold Bays-Muchmore at baysmuc2@illinois.edu or (425) 749-0004.

If you have any questions about your rights as a participant in this study or any concerns or complaints, please contact the University of Illinois Office for the Protection of Research Subjects at 217-333-2670 or via email at irb@illinois.edu.

Please print a copy of this consent form for your records, if you so desire.

I have read and understand the above consent form, I certify that I am 18 years old or older and, by clicking the submit button to enter the survey, I indicate my willingness voluntarily take part in the study.

APPENDIX H: Spring 2018 Survey Questionnaire

Question 4	My major was my ____ choice ❑ First ❑ Second ❑ Third ❑ Other
Question 5	Please rate the extent to which you agree with the following statements: ❑ I have a good understanding of my engineering major ❑ I have a good understanding of engineering as a profession ❑ I have a good understanding of the role engineers play in society ❑ I'm not sure what engineers in my field do professionally
Question 6	Please rate the extent to which you agree with the following statements: ❑ I feel confident in approaching coursework in my major ❑ I can get good grades in my classes ❑ I will be successful in my field ❑ I am just not good at engineering ❑ Engineering is too difficult for me ❑ I am good at math ❑ I am good at science ❑ Engineering is for students who are good at math and science
Question 7	Please rate the extent to which you agree with the following statements: ❑ I knew what major I wanted before I applied to college ❑ I am going to stay in my major ❑ I am happy with my major ❑ I am passionate about my major ❑ I am going to stay in the Engineering College ❑ I don't enjoy engineering ❑ I don't enjoy engineering coursework

Question 8	Please rate the extent to which the following statements agree with your idea of what engineers do ❑ Mainly work on machines and computers ❑ Mainly work with other people to solve problems ❑ Work on things that help the world ❑ Work on designing and improving things ❑ I don't know what engineers do ❑ Other (please specify)
Question 9	Compared to when I first started this school year.... ❑ I feel more confident about my success in engineering ❑ I understand my engineering major more ❑ I understand engineering as a field more
Question 10	Please indicate whether you believe the following experiences had positive or negative effects on your perception of engineering. If you feel neutral or did not have the experience, please select the neutral option. ❑ Attended a professor's office hours ❑ Attended a TA's office hours ❑ Worked on a group project ❑ Met with academic advisor ❑ Joined an engineering student organization ❑ Joined a non-engineering student organization ❑ Failed a test, paper, or project ❑ Attended a tutoring session ❑ Found a mentor (official or unofficial) ❑ Made a friend in my major

Question 11	Which of the following words agree with your idea of an engineer? Select all that apply. ❑ Confident ❑ Competitive ❑ Independent ❑ Big Picture Oriented ❑ Helpful ❑ Practical ❑ Kind ❑ Unimaginative ❑ Thrive under pressure ❑ Analytical ❑ Understanding ❑ Disorganized ❑ Loner ❑ Artistic ❑ Arrogant

APPENDIX I: Example Logistic Regression R Code

```
# Read Data for Question 8: I Chose Engineering because….

        q8 = read.csv("Q8.csv", header=T, na.strings=c(""))
        head(q8)

        # Names of variables:  ethnicity gender major prior math counselor parents
        ethnicity = as.factor(q8$ethnicity)
        gender = as.factor(q8$gender)
        major = as.factor(q8$major)

        # LOGISTIC MODEL SELECTION FOR PRIOR EXPERIENCE
#interactions model
        model1 = glm(q8$prior ~ ethnicity*gender*major, family=binomial(link="logit"),
data=q8)
        summary(model1)
#all factors
        model2 = glm(q8$prior ~ ethnicity + gender + major, family=binomial(link="logit"),
data=q8)
        summary(model2)
#gender as only factor
        model3 = glm(q8$prior ~ gender, family=binomial(link="logit"), data=q8)
        summary(model3)
```

APPENDIX J: Example Ordinal Regression R Code

```
require(foreign)
require(ggplot2)
require(MASS)
require(Hmisc)
require(reshape2)

 # Read Data for Question 4: What Choice was your Major?

        q4 = read.csv("Q4.csv", header=T, na.strings=c(""))
        head(q4)

        # Names of variables:  ethnicity gender major choice
        ethnicity = as.factor(q4$ethnicity)
        gender = as.factor(q4$gender)
        major = as.factor(q4$major)

        # ORDINAL MODEL FOR MAJOR CHOICE
        m_1 <- polr(as.factor(q4$choice) ~ ethnicity + gender+ major , data = q4, Hess=TRUE)

        ctable <- coef(summary(m_1))

        p <- pnorm(abs(ctable[, "t value"]), lower.tail = FALSE) * 2
        ctable <- cbind(ctable, "p value" = p)
        ctable
```