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An Investigative Study Into Student Motivation and Identity Among Upper Class Electrical and Computer Engineering Students

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An Investigative Study into Student Motivation and Identity among Upper Class Electrical and Computer Engineering Students

by

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Abstract

This study investigates upper-class electrical and computer engineering students' motivation and how students identify with their major. In addition, it also explores how student chosen research, projects, and learning impact the levels of motivation in students and how students identify with their major. Three different surveys were used over the course of the spring semester of 2017 at the University of Maine for this study: the Pittsburgh Freshman Engineering Aptitude Survey, the Project Ownership Survey, and the 2017 Electrical and Computer Engineering Survey. Participants for this study were junior and senior electrical and computer engineers, and students enrolled in ECE 466: Sensor Technology and Information. This study found that students exposed to research prior to the selection of a project, experienced increased levels of ownership and motivation for projects. Secondly, this study found that students experienced lower levels of motivation near the end of the semester when compared to the beginning.

Acknowledgements

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Table of Contents

1 Introduction 1
2 Purpose of Study 3
3 Development of ECE 466: Sensor Technology and Information 4
4 Study Limitations 5
5 Method 6
5.1 Pittsburgh Freshman Engineering Aptitude Survey 8
5.2 Project Ownership Survey 10
5.3 2017 Electrical and Computer Engineering Survey 11
6 Results 12
6.1 Study Habits of Students 13
6.1.1 Student Study Time 13
6.1.2 Individual Study vs. Group Study 16
6.2 Major Identity and Confidence 18
6.2.1 Subject Proficiency 18
6.2.2 Confidence in Major 22
6.2.3 Rewarding Major 25
6.3 Research in Learning 28
7 Discussion 32
7.1 Study Habits of Students 32
7.2 Major Identity and Confidence 34
7.3 Research in Learning 35
8 Future Work 36
9 Conclusion 37
10 Bibliography 39
11 Appendix I: Consent forms 41
12 Appendix II: Surveys 44
13 Appendix III: Survey Reponses 51
14 Appendix IV: IRB Approval Form 58
15 Author's Biography 59

List of Figures

Figure 1: Graduation rates in engineering 1
Figure 2: PFEAS responses on study habits 14
Figure 3: PFEAS responses to group and independent study 16
Figure 4: PFEAS responses on proficiency in several subjects 19
Figure 5: Student confidence in the major 22
Figure 6: Students opinions on failure 24
Figure 7: Students perspective on how rewarding Engineering is 26
Figure 8: Students dislike of Engineering 27
Figure 9: ECES responses on effectiveness of course activities 29
Figure 10: POS average responses 31

1 Introduction

As the advancement of technology continues to accelerate, the amount of knowledge science and engineering students need to master before entering the workforce also increases. This trend is true for other fields as well. Within the last 50 years, the level of education required to find employment has dramatically increased. In 1965 less than 13% of the US adult population had completed a four year degree [1, p. 28] compared to 2015 where over 32% of the US adult population had completed a four year degree [2, p. 2]. However, even though enrollments in engineering have been consistently increasing, the percentage of students graduating is continuously decreasing [3]. Figure 1 shows the number of seniors enrolled in engineering and number of graduating students in engineering in the United States.

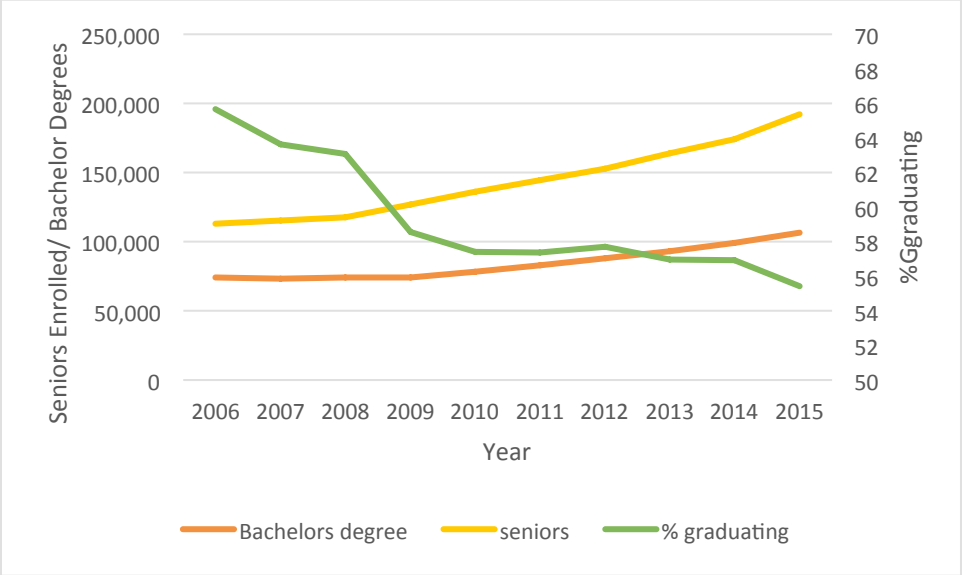

Figure 1: Graduation rates in engineering [3]

The percentage of students graduating engineering has decreased almost 10% over the past nine years and if the trend continues, graduation rates will only continue to decline.

Engineering students are found to spend the highest average levels of time spent studying for undergraduate degrees when compared to all other majors. The National Survey of Student Engagement (NSSE) found that students enrolled in engineering courses spend on average 19 hours per week preparing for class in 2013 [4], four more hours than the national average. The same study found that students in engineering majors are more than twice as likely as business majors to spend more than 20 hours a week studying. With the increasing amount of time required to study, many students lack the motivation necessary to excel or even succeed in engineering. In the same NSSE study, close to 22% of engineering seniors claimed that they often or very often came to class without completing all their homework, compared with 14-16% of seniors in other majors.

Additionally, the NSSE 2012 study found that on average, students spend 5 to 8 hours more per week preparing for class than what faculty believed they spent [5]. Facing increasing workloads for engineering students, the number of students lacking the motivation to complete the work will also increase. Proper management of this snowballing issue is of great importance.

Thus, the goal of this study is to measure the level of motivation in upper class electrical and computer engineering students, and to examine how they identify and relate with their major. Relationships between student motivation and student based research, projects and learning are explored as well. There are three groups of interest: 1) Students in their junior year completing their first semester for the design project, ECE 401/5; 2)

seniors during the final semester of their design project, ECE 403; and 3) students in the newly redeveloped course ECE 466: Sensor Technology and Information. The ECE senior design project is a three-semester long project course that is required for all electrical and computer engineering majors. ECE 466 is a laboratory- and project-based elective course. All three of the groups were surveyed at both the beginning and the end of the semester to detect shifts in motivation. Surveys were also given at the end of the semester to all groups to gauge students level of ownership of projects worked on or completed during the semester.

2 Purpose of Study

The inspiration for this study came from my time during the National Science Foundation Research Experience for Undergraduate students, NSF REU, where I was working with Professor Pereira da Cunha to redevelop ECE 466 into a sensors laboratory, available to all STEM and science majors, and to cover a broader range of sensor devices. As I started my research with Professor Pereira da Cunha, I realized that there was much I needed to learn to redevelop ECE 466. I was looking at similar courses from other universities, learning more on how to use microprocessors and the operation of various sensors, and researching the sensor projects that I could apply to the course. During all of this research, I found myself more motivated as an engineer than when I was doing course work during the previous semester. This insight pushed me to incorporate a student based research portion to laboratory modules and the course project. In this study, I hypothesize that giving engineering students more freedom to choose projects and

research topics within their courses will have a positive impact on their motivation and strengthen their identification with their major.

3 Development of ECE 466: Sensor Technology and Information

During the NSF REU, Professor Pereira da Cunha and I developed a new sensors laboratory to be offered in the spring semester at the University of Maine. This course is intended to be offered as a continuation of the material learned in ECE 465: Introduction to Sensors. My focus in the creation of this course was the design, testing, and documentation of six laboratory modules. Each module covers a different type of sensing device: (i) temperature; (ii) optical; (iii) force; (iv) biomedical; (v) gas; and (vi) magnetic. Sensing device(s) were researched and selected for each module, the experimental procedure was developed and tested, and a manual describing the sensor device, experimental procedure and report was developed.

In designing this new course, Professor Pereira da Cunha and I had the goal to develop a course that covered a broad range of sensor topics and is not restricted to a specific major. Since many fields use sensors to gather data and measure the world around us, making ECE 466 available to all engineering and science majors would equip a wider range of students with the knowledge of both the operation and implementation of sensors. The course also targets the need to increase knowledge and awareness on means of acquiring data in the field, and thus proves to be valuable for improving measurements in the various academic fields. ECE 466 covers a range of sensor types, giving students hands on experience with many different sensing devices. To make the course available to all STEM or science majors, the only perquisite for the course is the introductory sensor course ECE 465. Also, the course is planned so that any circuit

design, troubleshooting, and analysis are simple and thoroughly described, and any code necessary for the module is given and carefully explained. This simplification allowed the focus of each module to center on investigation of the sensors and understanding of the sensing devices, rather than on electronics aspects, which might also be addressed or investigated depending on the student background and interest.

The course focuses on independent student research and investigation of sensors related to students' areas of interest, to prepare and encourage students to pursue graduate school or further research. The inspiration for promoting research within ECE 466 came from *Motivating Students* [6] which discusses the importance of undergraduate research and how research increases students' academic abilities and develop clearer interests into their field of study. Each of the laboratory modules is designed to equip students with a new skill or better understanding in sensor analysis, design, investigation, system design and construction, and implementation. In addition, continuing a pre-established initiative by Prof. Pereira da Cunha, a course project has been implemented, where the student has the opportunity to write and defend her/his own project, vote on the ones to be implemented, and research and implement a new sensor project within the course.

4 Study Limitations

The scope of this study is limited by the number of participants. Each of the three groups has under 25 participants, each group had varying numbers of participants for each of the surveys used, and several students did not complete all the surveys. ECE 466 had only four participants that completed the study, consisting of two undergraduates and two graduate students. The study occurring for only one semester also limits the scope of

the study. Extending the study over several years to compare the same group as they progress from juniors to seniors would be more ideal, instead of comparing the current junior and senior class at the university. The limited time of the study also limits the number of participants, where extending the study would allow for more participants to cycle through the study. Due to the small participant size, statistical significance, and time allotted for the study, certain conclusions will be limited.

5 Methodology

To gather data for this study, participants from the three groups were asked to complete several surveys. The surveying method was chosen for several reasons. First, it allowed for precise tracking of student motivation over the duration of a semester. Second, several tested surveys already existed that track student motivation, opinions and confidence. An additional survey was developed specifically for this study. Finally, the surveys selected for this study, all of which can be completed within 15 minute periods, maximized student participation. Three surveys were used for data collection: 1) the Pittsburgh Freshman Engineering Aptitude Survey, PFEAS [7]; 2) the Project Ownership Survey, POS [8], and; 3) the 2017 Electrical and Computer Engineering Survey, ECES. The PFEAS was selected as a survey for this study because it was tested and developed by the University of Pittsburgh to survey engineering students on opinions, motivations and confidence for engineering. The POS was selected to measure the participants' level of ownership of projects completed or worked on during the semester, as well as rating their opinions and feelings on the experience. The POS was created through a coordinated effort by the Universities of Pennsylvania, Pittsburgh and Georgia to test project ownership [8]. The ECES was developed at the University of Maine by Thomas

Leighton to gather data on participants' opinions of various courses they were taking during the spring semester of their junior and senior year in electrical/computer engineering. The survey also asks participants about various time commitments, ranking course activities and sleep habits.

Participants in the study were enrolled in ECE 466: Sensor Technology and Information, ECE 401: Electrical Engineering Design Project, ECE 405: Computer Engineering Design Project, and ECE 403: Electrical and Computer Engineering Design Project. The ECE senior project courses were selected for participant recruitment because all juniors and seniors in the ECE department are required to take this course; also, it provides a large group for the comparison of juniors to seniors as the semester progressed for the surveys. ECE 466 was selected because it was a newly developed sensors course, with a heavy focus on labs, research, and a research-based project.

For all surveys, participants were asked to give their name, major, academic year, and cumulative GPA. To ensure confidentiality, all names recorded were assigned a ten-digit identification number, both the identification key and recorded results were kept in password protected files. The collected survey data are stored in Professor Pereira da Cunha's office in Barrows Hall. The demographics of the survey participants for both the PFEAS given at the beginning of the semester (pre) and the PFEAS at the end of the semester (post), as well as the POS and the ECES are shown in Table 1 below.

Table 1: Survey Demographics of current study

Gender	PFEAS(pre) (N = 48)	PFEAS (post) (N = 38)	POS (N = 37)	ECES (N = 27)
M	44	37	36	26
F	2	1	1	1
Year				
SO	1	1	1	0

JR	16	14	12	11
SR	27	21	22	16
GRAD	2	2	2	0
Course				
ECE 403	22	20	20	15
ECE 401/405	21	14	13	12
ECE466	5	4	4	0
Cumulative GPA				
2.00-2.49	3	2	4	2
2.50-2.99	11	3	4	2
3.00-3.49	14	11	12	11
3.50-4.00	17	14	11	10
Major				
Electrical Engineer	13	17	14	9
Electrical & Computer Engineer	6	4	5	4
Computer Engineer	21	13	16	13
OTHER	8	4	2	1

The general consent form and the consent form for ECE 466 participants can be found in Appendix 1: Consent forms. The PFEAS, POS, and ECES are discussed in the following sections. The full versions of the PFEAS, POS, and ECES can be found in Appendix II: Surveys.

5.1 Pittsburgh Freshman Engineering Aptitude Survey

The Pittsburgh Freshman Engineering Aptitude Survey, PFEAS, is a 70-question survey related to student's attitudes and perspective on studying engineering and engineering related topics [7]. Sixty-nine survey questions use a Likert scale with the following values: Strongly Disagree-1 Disagree-2 Neutral-3 Agree-4 Strongly Agree-5; or Not Strongly Confident-1 Not Confident-2 Neutral-3 Confident-4 Strongly Confident-5. The following instructions are given at the start of the survey: "**This is a survey to**

elicit engineering student's opinions and feelings about engineering. Please do not spend more than 15 minutes to complete the questionnaire, so work as quickly as you can. Complete the following information as instructed." The first question of the survey is a short answer question. The next thirty-four questions are prompted with the following instructions: "**For each statement, please fill in the number that corresponds to how strongly you disagree or agree with the statement."** Typical statements include [7]:

11. Engineers are well paid.	O 1	O 2	O 3	O 4	O 5
12. Engineers contribute more to making the world a better place than people in most other occupations.	O 1	O 2	O 3	O 4	O 5
13. Engineers are innovative.	O 1	O 2	O 3	O 4	O 5
14. I enjoy the subjects of science and mathematics the most.	O 1	O 2	O 3	O 4	O 5
15. I will have no problem finding a job when I have obtained an engineering degree.	O 1	O 2	O 3	O 4	O 5
16. Engineering is an exact science.	O 1	O 2	O 3	O 4	O 5

The next seven survey questions prompt the students to rate their confidence levels in several subjects: Chemistry, Physics, Calculus, Engineering, Writing, Speaking, and Computer Skills.

The remaining questions are prompted with the following instructions: "**For the following statements about studying, working in groups and personal abilities, please fill in the number corresponding to the response that best describes how strongly you disagree or agree with the statements."** Typical statements include [7]:

52. In the past, I have not enjoyed working in assigned groups.	O 1	O 2	O 3	O 4	O 5
53. I am confident about my current study habits or routine.	O 1	O 2	O 3	O 4	O 5
54. I consider myself mechanically inclined.	O 1	O 2	O 3	O 4	O 5
55. I consider myself technically inclined.	O 1	O 2	O 3	O 4	O 5

The PFEAS was chosen as a tool to measure student motivation and student identity as the participants progressed through the spring semester of 2017. Tracking shifts in motivation and identity as the semester progressed allowed speculation on the influencing factors being attributed to the courses taken that semester or other possible factors. Participants in the study were given the survey in the beginning of the semester and near the conclusion of the semester. The results gathered from the PFEAS given at the beginning of the survey were compared to the results of the PFEAS survey given at the end of the semester.

5.2 Project Ownership Survey

The Project Ownership Survey, POS, is a 16-questions survey related to student's ownership of projects and research, and gauges student perspective on laboratory based courses [8]. All sixteen survey questions use a Likert scale with the following values: Strongly Disagree-1 Disagree-2 Neutral-3 Agree-4 Strongly Agree-5; or Very Slightly-1 Slightly-2 Moderate-3 Considerably-4 Very Stongly-5. The first 10 ask the students to respond to statements about their research or project. Typical statements included [8]:

The research question I worked on was important to me.	□	□	□	□	□
In conducting my research project, I actively sought advice and assistance.	□	□	□	□	□
My research project was interesting.	□	□	□	□	□

The final six question ask the students to respond to statements about laboratory course experiences. Typical statements include [8]:

To what extent does the word *joyful* describe your experience of the laboratory course?	□	□	□	□	□
To what extent does the word *astonished* describe your experience of the laboratory course?	□	□	□	□	□
To what extent does the word *surprised* describe your experience of the laboratory course?	□	□	□	□	□

This survey was given to participants in ECE 401, ECE 403 and ECE 405 at the completion of the senior presentations, April 24th. The survey was given on April 25th to ECE 466 participants, the week prior to their final project presentations.

5.3 2017 Electrical and Computer Engineering Survey

The 2017 Electrical and Computer Engineering Survey, ECES, is a ten-question survey about students' time commitment, retention of course material, and retention from various teaching tools. The first question asks students to indicate the average time per week they spend on a course they are currently taking, courses included are: ECE 486, ECE 403, ECE 343, ECE 414, ECE 401/5, ECE 477, ECE 331, COS 431, ECE 478, and ECE 444. The next three questions ask students if they live off campus, their average one-way commute time, and time commitment to student organizations. Questions 5 and 6 ask the students about their sleeping habits. Question 7 asks about the time commitment of ongoing employment during the semester. Question 8 and 10 ask the students to indicate the expected GPA for courses they are currently taking and the level of retention and skill gained form each course. Question 9 asks the students to rank the following activities based on personal retention and preference: lecture, assigned reading, homework (weekly), homework (daily), labs, projects (assigned topic), projects (student-chosen topic), exams, recitation, and individual study.

This survey was given to participants in ECE 401, ECE 403 and ECE 405 at the same time as the POS. Since the ECES was designed for junior and senior electrical and computer engineering students, the participants in ECE 466 were not given the survey because participants may have been from outside the target group.

6 Results

The responses of the three surveys was analyzed using Excel. The mean response and standard deviation for each of the Likert scale questions were found. Since the sample size for most of the surveys is small as well as varying between groups and surveys, most of the data point comparisons between the three groups are not statistically significant. Therefore, the mean and standard deviation of each of the groups are used to speculate about correlations from the data collected through the trends realized when comparing the mean responses and standard deviations. The mean and standard deviation for each question were determined using all participants from each of the three groups: ECE 466, ECE 403 and ECE 401/5. This section will present the results from the three surveys that will be discussed in the Discussion section.

Standard deviations were used to assess differences in means among all groups for each question. When analyzing the PFEAS, pre- (1) and post- (2) surveys. In the following sections, to distinguish between pre- and post-surveys, the mean and standard deviations are labeled M and SD respectively, followed by a 1 or 2 sub designator to indicating pre- or post-PFEAS respectively (M_1= ##, SD_1= ##; M_2= ##, SD_2= ##). The results from the pre- and post-PFEAS found in this are presented next to data reported in a study on first year civil engineering students from The Citadel, The Military College of South Carolina, (n=66 pre-PFEAS, and n=68 post-PFEAS) given at the start and end of a

semester [9]. Not all responses from the PFEAS survey found in The Citadel study were reported and therefore not all questions' responses will be compared to the study. Results from the Project Ownership Survey are compared to results from the study developing the POS, where participants were undergraduates enrolled in laboratory courses at 21 different institutions in the United States (n=68) [8]. Tables showing the means, standard deviations and differences between participating groups' values found for this study on the University of Maine participants are in Appendix III: survey responses.

6.1 Study Habits of Students

The study habits of participants were investigated to see what effect courses in which the participants were enrolled had on motivation during the semester. Comparing responses from the PFEAS given at the start of the semester to the PFEAS given at the end of the semester, several correlations were revealed. The mean responses and standard deviations found for each question of PFEAS is in Appendix III: Survey Responses, Table 2 and Table 3.

6.1.1 Student Study Time

PFEAS questions 46, 53, 64 and 67 ask students to rate their study habits. Question 46, 53, 64 and 67 are as follows:

46. I need to spend more time studying than I currently do.

53. I am confident about my current study habits or routine.

64. I keep up in my classes my mastering the material presented in the last class meeting before the next class meeting.

67. I would give myself an A+ on the amount of time and energy I devote to my studies.

The average responses to these questions by the three course groups for both the pre- and post-PFEAS given is shown in Figure 2 below.

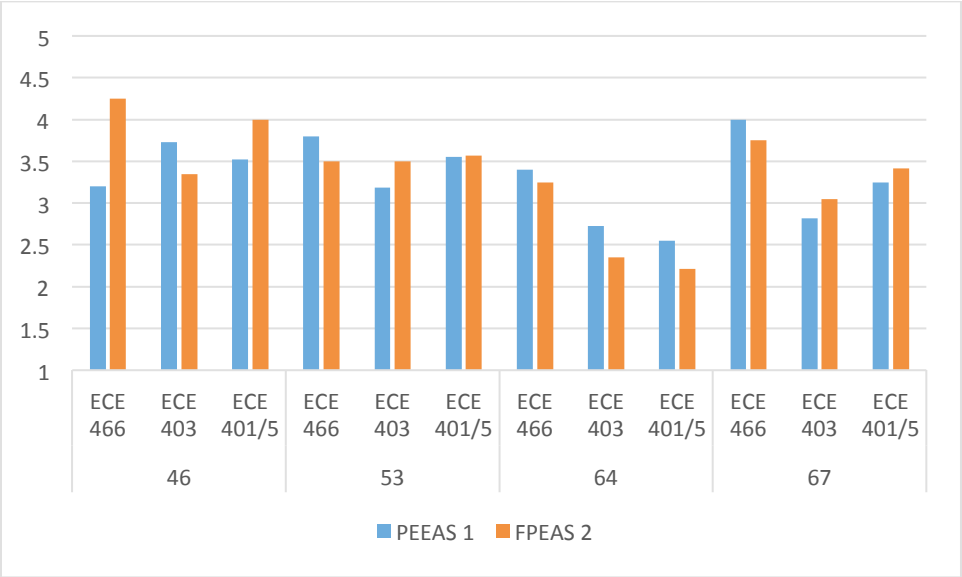

Figure 2: PFEAS responses on study habits

On question 46 (I need to spend more time studying than I currently do), all groups responded that they should spend more time studying than they currently do. Participants from ECE 466 (M_1= 3.2, SD_1= 1.48; M_2= 4.25, SD_2= 0.96) had the highest increase in the mean response. They were followed by participants from ECE 403 (M_1= 3.727, SD_1= 0.883; M_2= 3.350, SD_2= 1.167), which were also the only group to show a decrease from pre- to post-PFEAS. Participants from ECE 401/5 (M_1= 3.524, SD_1= 1.167; M_2= 4.000, SD_2= 1.109) showed an increased response from pre- to post-PFEAS. Responses from The Citadel study for this question (M_1= 4.17, SD_1= 0.83; M_2= 3.99, SD_2= 0.98) had higher initial mean responses than the University of Maine participants.

Overall, the responses from all participating groups changed from pre- to post-PFEAS on question 53 (I am confident about my current study habits or routine). Participants from ECE 466 (M_1= 3.8, SD_1= 0.837; M_2= 3.5, SD_2= 1.732) decreased slightly in the mean from pre- to post-PFEAS. Participants from ECE 403 (M_1= 3.182, SD_1= 0.795; M_2= 3.500, SD_2= 0.761) increased in the mean response from pre- to post-PFEAS, and participants from ECE 401/5 (M_1= 3.550, SD_1= 1.050; M_2= 3.571, SD_2= 0.938) showed almost no change (less than .05) from pre- to post- PFEAS in the mean response. Responses from The Citadel study for this question (M_1= 3.27, SD_1= 0.85; M_2= 3.49, SD_2= 1.03) had similar responses to the University of Maine participants.

Responses from all groups showed a decrease in the mean response from pre- to post-PFEAS on question 64 (I keep up in my classes by mastering the material presented in the last class meeting before the next class meeting). Participants from ECE 466 (M_1= 3.4, SD_1= 1.140; M_2= 3.25, SD_2= 1.709) gave the highest responses on both pre- to post-PFEAS, participants from ECE 403 (M_1= 2.727, SD_1= 0.703; M_2= 2.350, SD_2= 0.875) decreased slightly from pre-to post-, and participants from ECE 401/5 (M_1= 2.550, SD_1= 0.605; M_2= 2.214, SD_2= 0.893) decreased from pre- to post-PFEAS.

The responses for question 67 (I would give myself an A+ on the amount of time and energy I devote to my studies) by all groups had minimal shifts in responses from pre- to post-PFEAS. Participants from ECE 466 (M_1= 4.000, SD_1= 1.000; M_2= 3.750, SD_2= 1.893) gave the highest responses on both pre- to post-PFEAS, participants from ECE 403 (M_1= 2.818, SD_1= 0.958; M_2= 3.050, SD_2= 1.146) increased slightly from pre- to post-PFEAS, and participants from ECE 401/5 (M_1= 3.250, SD_1= 1.070; M_2= 3.417, SD_2= 0.996) increased from pre- to post- PFEAS.

6.1.2 Individual Study vs. Group Study

PFEAS questions 44, 50, 52, and 61 ask students to on their opinions on independent versus group study/work. Question 44, 50, 52, and 61 are as follows:

44. Studying in a group is better than studying by myself.

50. I prefer studying/working alone.

52. In the past, I have not enjoyed working in assigned groups.

61. I prefer to solve difficulties on my own, without seeking help from others.

The mean response from the ECE 466, ECE 403 and ECE 401/5 groups on the pre- and post-PFEAS for questions 44, 50, 52, and 61 listed above are shown in Figure 3 below.

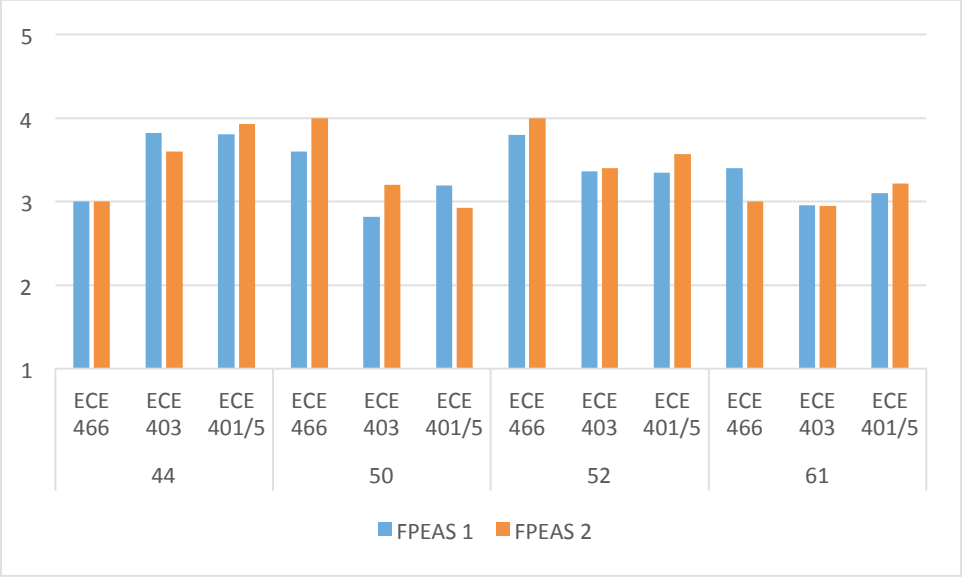

Figure 3: PFEAS responses to group and independent study

For Question 44 (Studying in a group is better than studying by myself), participants from ECE 466 (M_1= 3.000, SD_1= 0.707; M_2= 3.000, SD_2= 3.000) had the lowest mean response of the three groups and no change from the pre- to post-PFEAS.

Participants from ECE 403 (M_1= 3.818, SD_1= 0.958; M_2= 3.600, SD_2= 0.754), which were also the only group to show a decrease in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M_1= 3.810, SD_1= 1.078; M_2= 3.929, SD_2= 0.754) showed an increased response mean from pre- to post-PFEAS. Responses from The Citadel study for this question (M_1= 3.70, SD_1= 0.88; M_2= 4.02, SD_2= 0.95) had similar responses to the University of Maine participants.

For Question 50 (I prefer studying/working alone), participants from ECE 466 (M_1= 3.600, SD_1= 0.894; M_2= 4.000, SD_2= 1.155) had the highest mean response of the three groups. Participants from ECE 403 (M_1= 2.818, SD_1= 0.907; M_2= 3.200, SD_2= 0.997) showed an increase in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M_1= 3.190, SD_1= 1.250; M_2= 2.929, SD_2= 0.997) showed a decreased response mean from pre- to post-PFEAS. Responses from The Citadel study for this question (M_1= 3.09, SD_1= 1.00; M_2= 3.44, SD_2= 1.03) had similar responses to the ECE 401 and 401/5 participants.

For Question 52 (In the past, I have not enjoyed working in assigned groups), participants from ECE 466 (M1= 3.8, SD1= 0.837; M2= 4, SD2= 0.816) had the highest mean response of the three groups. The next highest mean response came from participants enrolled in ECE 403 (M1= 3.364, SD1= 0.848; M2= 3.4, SD2= 0.821). The mean response from pre- to post-PFEAS from the ECE 403 participants showed almost no change. Participants from ECE 401/5 (M1= 3.35, SD1= 1.04; M2= 3.571, SD2= 0.852) showed an increased response mean from pre- to post-PFEAS. Responses from The Citadel study for this question (M_1= 3.11, SD_1= 1.04; M_2= 3.00, SD_2= 0.96) had lower initial mean responses than the University of Maine participants.

For Question 61 (I prefer to solve difficulties on my own, without seeking help from others), participants from ECE 466 (M1= 3.4, SD1= 1.14; M2= 3, SD2= 1.826) had decrease in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 2.955, SD1= 0.844; M2= 2.95, SD2= 0.887) showed almost no change in the mean response from pre- to post-PFEAS and had the lowest mean response. Participants from ECE 401/5 (M1= 3.1, SD1= 1.21; M2= 3.214, SD2= 1.051) showed an increased response mean from pre- to post-PFEAS.

6.2 Major Identity and Confidence

The responses given from the three groups on the PFEAS also indicated some trends in how participants identified with engineering, as well as their levels of confidence with engineering. This section highlights data gathered through the pre- and post-PFEAS relating to how participants identified with engineering and their levels of confidence in engineering.

6.2.1 Subject Proficiency

Questions 36 through 42 on the PFEAS asked students to rate their proficiency in several subjects. The mean responses of participants are shown in Figure 4 below.

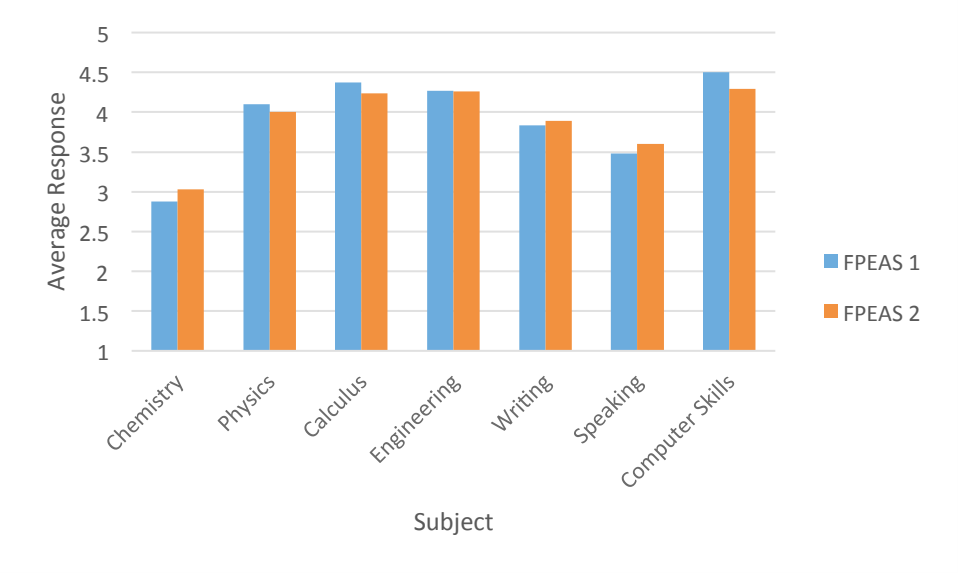

Figure 4: PFEAS responses on proficiency in several subjects

Figure 4 above shows the mean response for each of the subject responses for the three combined groups. The combined groups response for the subjects are as follows:

1. Computer Skills (M1= 4.5, SD1= 0.619; M2= 4.289, SD2= 0.898)
2. Speaking (M1= 3.479, SD1= 0.989; M2= 3.605, SD2= 1.028)
3. Writing (M1= 3.833, SD1= 0.907; M2= 3.895, SD2= 1.085)
4. Engineering (M1= 4.271, SD1= 0.707; M2= 4.263, SD2= 0.76)
5. Calculus (M1= 4.375, SD1= 0.733; M2= 4.237, SD2= 0.714)
6. Physics (M1= 4.104, SD1= 0.778; M2= 4, SD2= 0.838)
7. Chemistry (M1= 2.875, SD1= 0.981; M2= 3.026, SD2= 1)

For Question 36, Chemistry, participants from ECE 466 (M1= 3.2, SD1= 1.095; M2= 3, SD2= 1.826) had decrease in the mean response from the pre- to post-PFEAS. Participants enrolled in ECE 403 (M1= 2.682, SD1= 0.995; M2= 3, SD2= 1.026) had an increase in the mean response from pre- to post-PFEAS. Participants from ECE 401/5

(M1= 3, SD1= 0.949; M2= 3.071, SD2= 0.73) showed almost no change response mean from pre- to post-PFEAS.

For Question 37, Physics, participants from ECE (M1= 4.2, SD1= 1.095; M2= 4, SD2= 2) had decrease in the mean response from the pre- to post-PFEAS. Participants enrolled in ECE 403 (M1= 4.091, SD1= 0.684; M2= 4, SD2= 0.562) showed a decrease in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 4.095, SD1= 0.831; M2= 4, SD2= 0.784) showed a decreased response mean from pre- to post-PFEAS.

For Question 38, Calculus, participants from ECE 466 (M1= 4.6, SD1= 0.894; M2= 3.5, SD2= 1.732) had decrease in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 4.091, SD1= 0.811; M2= 4.25, SD2= 0.444) had the lowed mean response and showed an increase in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 4.619, SD1= 0.498; M2= 4.429, SD2= 0.514) showed a decreased response mean from pre- to post-PFEAS.

For Question 39, Engineering, participants from ECE 466 (M1= 4.2, SD1= 0.837; M2= 3.75, SD2= 1.893) had a decrease in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 4.182, SD1= 0.733; M2= 4.3, SD2= 0.47) was the only group to show an increase in the mean response to this question from pre- to post-PFEAS. Participants from ECE 401/ (M1= 4.381, SD1= 0.669; M2= 4.357, SD2= 0.633) showed a decreased response mean from pre- to post-PFEAS.

For Question 40, Writing, participants from ECE 466 (M1= 4.2, SD1= 0.837; M2= 3.75, SD2= 1.893) had a decrease in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 3.864, SD1= 0.56; M2= 3.9, SD2= 0.912)

showed an increase in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 3.714, SD1= 1.189; M2= 3.929, SD2= 1.141) showed an increased response mean from pre- to post-PFEAS.

For Question 41, Speaking, participants from ECE 466 (M1= 3.2, SD1= 1.095; M2= 3, SD2= 1.633) had a decrease in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 3.455, SD1= 0.858; M2= 3.55, SD2= 0.887) had an increase in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 3.571, SD1= 1.121; M2= 3.857, SD2= 1.027) showed an increased response mean from pre- to post-PFEAS.

For Question 42, Computer Skills, participants from ECE (M1= 4.2, SD1= 0.837; M2= 3.5, SD2= 1.732) had a decrease in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 4.545, SD1= 0.596; M2= 4.4, SD2= 0.754) realized a decrease in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 4.524, SD1= 0.602; M2= 4.357, SD2= 0.745) showed a decreased response mean from pre- to post-PFEAS.

The mean and standard deviation of the responses from The Citadel study for questions 36 – 42 is shown in Table 2 below.

Table 2: Citadel pre- and post-PFEAS results [9]

Question	*M1*	*SD1*	*M2*	*SD2*
Chemistry	3.64	0.87	3.27	1.11
Physics	3.62	0.94	3071	0.77
Calculus	3.68	0.86	3.94	0.86
Engineering	4.08	0.77	4037	0.64

Writing	3.26	1.00	3.71	0.99
Speaking	3.83	0.94	4.06	0.94
Computer Skills	3.82	0.91	4.15	0.73

6.2.2 Confidence in Major

PFEAS questions 49, 58, 69, and 69 ask students on their confidence to succeed in engineering. Question 49, 58, 69, and 69 are as follows:

49. I feel confident in my ability to succeed in engineering.
58. I am confident that I will succeed in engineering study.
68. I am certain that I want to graduate in engineering.
69. I am certain that I will be able to graduate in engineering.

The mean response from the ECE 466, ECE 403 and ECE 401/5 groups on the pre- and post-PFEAS for questions 49, 58, 68, and 69 listed above are shown in Figure 5 below.

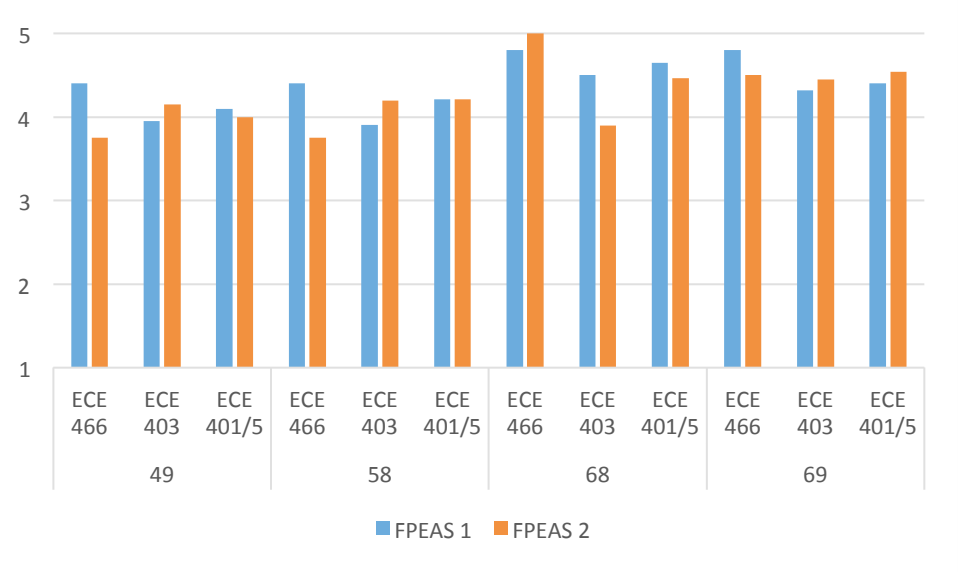

Figure 5: Student confidence in the major

For Question 49 (I feel confident in my ability to succeed in engineering), participants from ECE 466 (M1= 4.4, SD1= 0.894; M2= 3.75, SD2= 1.893) had a

decrease from the pre- to post-PFEAS. Participants enrolled in ECE 403 (M1= 3.955, SD1= 0.653; M2= 4.15, SD2= 0.587) were the only group to show an increase in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 4.095, SD1= 0.944; M2= 4, SD2= 0.784) showed almost no change in the response mean from pre- to post-PFEAS. Responses from The Citadel study for this question (M_1= 4.39, SD_1= 0.68; M_2= 4.35, SD_2= 0.73) had higher mean responses than the ECE 403 and 401/5 participants.

For Question 58 (I am confident that I will succeed in engineering study), participants from ECE 466 (M1= 4.4, SD1= 0.894; M2= 3.75, SD2= 1.893) had a decrease from the pre- to post-PFEAS. Participants from ECE (M1= 3.909, SD1= 0.526; M2= 4.2, SD2= 0.523) were the only group to show an increase in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 4.211, SD1= 0.787; M2= 4.214, SD2= 0.699) showed almost no change in the response mean from pre- to post-PFEAS.

For Question 68 (I am certain that I want to graduate in engineering), participants from ECE 466 (M1= 4.8, SD1= 0.447; M2= 5, SD2= 0) had the lowest mean response of the three groups and had an increase in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 4.5, SD1= 0.598; M2= 3.9, SD2= 1.119) showed a decrease in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 4.65, SD1= 0.489; M2= 4.462, SD2= 0.877) showed a decreased response mean from pre- to post-PFEAS.

For Question 69 (I am certain that I will be able to graduate in engineering), participants from ECE 466 (M1= 4.8, SD1= 0.447; M2= 4.5, SD2= 1) realized a decrease

in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 4.318, SD1= 0.568; M2= 4.45, SD2= 0.51) showed an increase in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 4.4, SD1= 0.681; M2= 4.538, SD2= 0.66) showed an increased response mean from pre- to post-PFEAS.

PFEAS questions 59 and 60 ask students on their perspective of their failures in engineering. Question 59 and 60 are as follows:

59. I have a tendency to sabotage my success.

60. When I experience failures, it is usually someone else's fault.

The mean response from the ECE 466, ECE 403 and ECE 401/5 groups on the pre- and post-PFEAS for questions 59 and 60 listed above are shown in Figure 6 below.

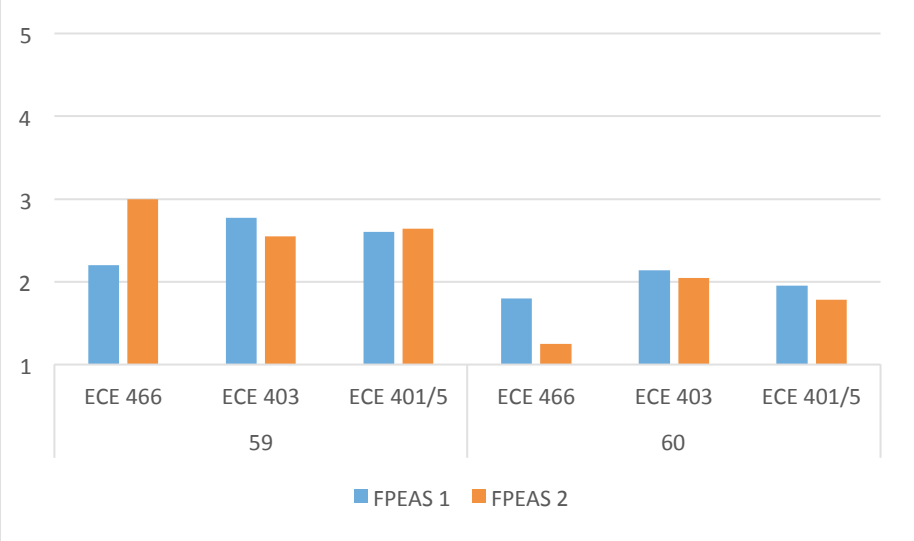

Figure 6: Students opinions on failure

For Question 59 (I have a tendency to sabotage my success), participants from ECE 466 (M1= 2.2, SD1= 0.837; M2= 3, SD2= 1.414) had an increase in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 2.773, SD1= 1.152; M2= 2.55, SD2= 0.945) showed a decrease in the mean response from pre- to

post-PFEAS. Participants from ECE 401/5 (M1= 2.6, SD1= 0.94; M2= 2.643, SD2= 1.151) showed almost no change in the response mean from pre- to post-PFEAS.

For Question 61(When I experience failures, it is usually someone else's fault), participants from ECE 466 (M1= 3.4, SD1= 1.14; M2= 3, SD2= 1.826) had a decrease from the pre- to post-PFEAS. Participants from ECE (M1= 2.955, SD1= 0.844; M2= 2.95, SD2= 0.887) showed almost no change in the mean response from pre- to post-PFEAS. Participants from ECE 401/5 (M1= 3.1, SD1= 1.21; M2= 3.214, SD2= 1.051) showed an increased response mean from pre- to post-PFEAS.

6.2.3 Rewarding Major

PFEAS questions 2, 3, 4, and 6 ask students to rate how rewarding engineering is to them. Question 2, 3, 4, and 6 are as follows:

2. I expect that engineering will be a rewarding career.
3. I expect that studying engineering will be rewarding.
4. The advantages of studying engineering outweigh the disadvantages.
6. The future benefits of studying engineering are worth the effort.

The mean response from the ECE 466, ECE 403 and ECE 401/5 groups on the pre- and post-PFEAS for questions 2, 3, 4, and 6 listed above are shown in Figure 7 below.

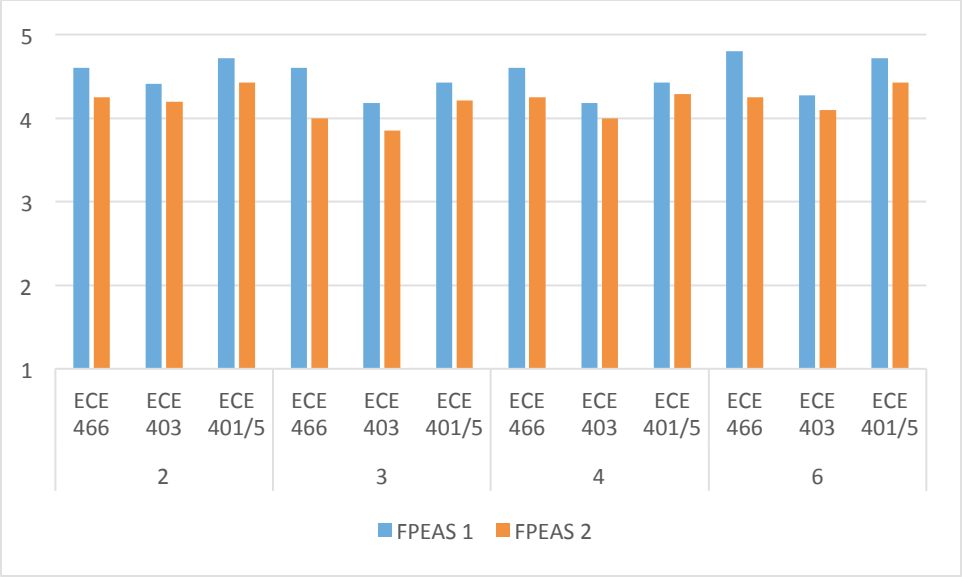

Figure 7: Students perspective on how rewarding Engineering is

The response from all groups in for questions 2, 3, 4, and 6 all had a decrease in the mean response from pre- to post-PFEAS. The trend revealed through this decrease in mean response indicates students' opinions on engineering decrease as the semester progresses. The mean and standard deviation of the responses from The Citadel study for questions 2, 3, 4, and 6 is shown in Table 3 below.

Table 3: Citadel pre- and post- PFEAS responses [9]

Question	*M1*	*SD1*	*M2*	*SD2*
2	4.74	0.47	4.78	0.42
3	4.67	0.54	4.72	0.48
4	4.58	0.54	4.65	0.59
6	4.71	0.46	4.63	0.57

PFEAS questions 5, 7, and 9 ask students about their levels of satisfaction in engineering. Question 5, 7, and 9 are as follows:

5. I don't care for this career.

7. I can think of several other majors that would be more rewarding than engineering.

9. The rewards of getting an engineering degree are not worth the effort.

The mean response from the ECE 466, ECE 403 and ECE 401/5 groups on the pre- and post-PFEAS for questions 5, 7, and 9 listed above are shown in Figure 8 below.

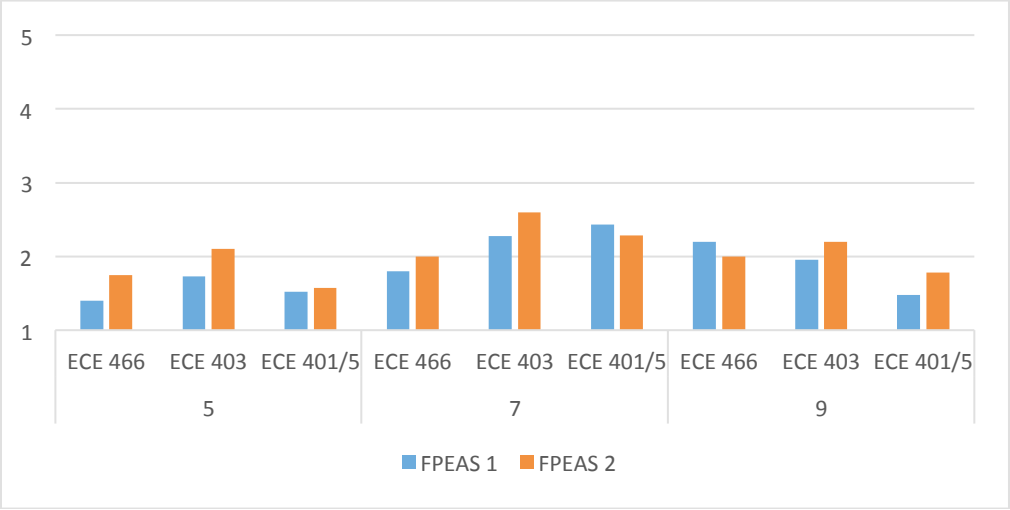

Figure 8: Students dislike of Engineering

For Question 5 (I don't care for this career), participants from ECE 466 (M1= 1.4, SD1= 0.548; M2= 1.75, SD2= 1.5) had an increase in the mean response from the pre- to post-PFEAS. Participants from ECE 403 (M1= 1.727, SD1= 0.55; M2= 2.1, SD2= 1.021) showed an increase in the mean response from pre- to post-PFEAS for this question. Participants from ECE 401/5 (M1= 1.524, SD1= 0.602; M2= 1.571, SD2= 0.756) showed almost no change in the response mean from pre- to post-PFEAS. Responses from The Citadel study for this question (M_1= 1.35, SD_1= 0.57; M_2= 1.38, SD_2= 0.42) had lower mean responses than the University of Maine participants.

For Question 7 (I can think of several other majors that would be more rewarding than engineering), participants from ECE 466 (M1= 1.8, SD1= 0.837; M2= 2, SD2=

1.414) had an increase in the mean response from the pre- to post-PFEAS. Participants enrolled in ECE 403 (M1= 2.273, SD1= 0.827; M2= 2.6, SD2= 1.046) realized an increase in the mean response from pre- to post-PFEAS for this question. Participants from ECE 401/5 (M1= 2.429, SD1= 1.028; M2= 2.286, SD2= 0.825) showed a decreased response mean from pre- to post-PFEAS. Responses from The Citadel study for this question (M_1= 2.23, SD_1= 0.87; M_2= 2.24, SD_2= 0.92) had similar responses to the University of Maine participants.

For Question 9 (The rewards of getting an engineering degree are not worth the effort), participants from ECE 466 (M1= 2.2, SD1= 1.643; M2= 2, SD2= 0.816) showed a decrease from the pre- to post-PFEAS. Participants from ECE 403 (M1= 1.955, SD1= 0.722; M2= 2.2, SD2= 0.894) showed an increase in the mean response from pre- to post-PFEAS for this question. Participants from ECE 401/5 (M1= 1.476, SD1= 0.512; M2= 1.786, SD2= 0.802) showed an increased response mean from pre- to post-PFEAS. Responses from The Citadel study for this question (M_1= 1.42, SD_1= 0.77; M_2= 1.57, SD_2= 0.82) had lower mean responses than the University of Maine participants.

6.3 Research in Learning

In the ECES, participants were asked to rate various activities that they have done through their course work in terms personal retention of the knowledge and skills gained from the course. The mean responses for each of the course activities by all groups collectively are shown in Figure 9 below.

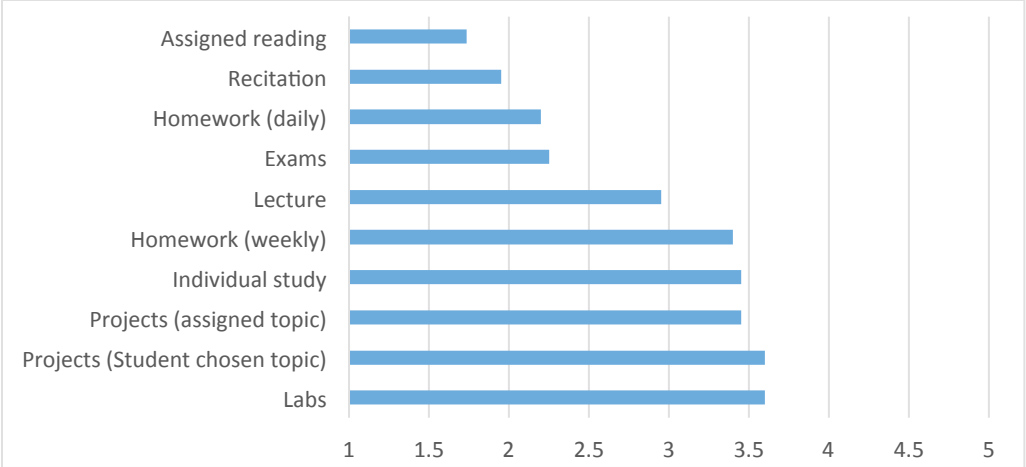

Figure 9: ECES responses on effectiveness of course activities

The mean of the responses for the ECES was found using all participants. The mean response, M, and standard deviation, SD, to each of the course activities are as follows:

Labs (M= 3.6, SD= 0.598)

Projects (Student chosen topic) (M= 3.6, SD= 1.046)

Projects (assigned topic) (M= 3.45, SD= 0.945)

Individual study (M= 3.45, SD= 1.05)

Homework (weekly) (M= 3.4, SD= 0.995)

Lecture (M= 2.95, SD= 1.234)

Exams (M= 2.25, SD= 1.07)

Homework (daily) (M= 2.2, SD= 1.056)

Recitation (M= 1.95, SD= 1.05)

Assigned reading (M= 1.737, SD= 0.933)

Activities such as labs and projects, were indicated by participants to yield higher rates of retention that activities such as assigned reading, recitation and exams.

The first 10 questions on the POS asked participants to indicate their opinions on their research/projects that they completed or worked on over the semester during the study. The first 10 questions from the POS are as follows:

1. My research will help to solve a problem in the world.
2. My findings were important to the scientific community.
3. I faced challenges that I managed to overcome in completing my research project.
4. I was responsible for the outcomes of my research.
5. The findings of my research project gave me a sense of personal achievement.
6. I had a personal reason for choosing the research project I worked on.
7. The research question I worked on was important to me.
8. In conducting my research project, I actively sought advice and assistance.
9. My research project was interesting.
10. My research project was exciting.

Figure 10 below shows the mean responses of the ECE 404, ECE 401/5 and ECE 466 groups to the first 10 questions on the POS.

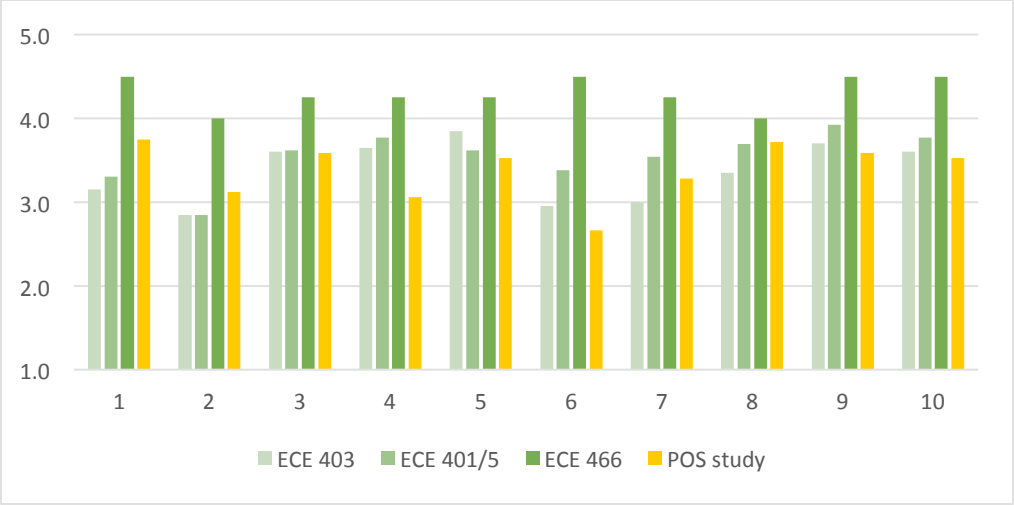

Figure 10: POS average responses

Doing an ANOVA test on the data when comparing the ECE 403 and ECE 466 groups yields the P-Values as shown in the Table 4 below. A P-value, or probability value, is the likelihood that for a given statistical model that, where the null hypothesis is true, the statistical summary (for this instance the sample mean difference between two groups) would be the equivalent to (lower P-value the desired threshold) or more extreme (higher than the desired threshold) than the actual observed results.

Table 4: P-Values results of POS responses

Question	P-Value
1	0.001144
2	0.011403
3	0.026714
4	0.126867
5	0.221851
6	0.005435
7	0.017319
8	0.0851
9	0.026234
10	0.015854
11	0.000619
12	0.003214
13	0.038154

14	0.47084
15	0.47084
16	0.364464

Questions that have a P-Value less than 0.05 are found to be statistically significant, which are question 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, and 13. Questions 4, 5, 14, 15, and 16 have no statistical difference when comparing the ECE 403 and ECE 466 groups.

7 Discussion

The mean and standard deviation data can be used to speculate on data collected from the surveys for correlations among the three groups. This section focuses on three categories from the three surveys given: the study habits of students, levels of confidence and identity with engineering, and the role of research in learning. Tracking the study habits of participants over the course of the semester can indicate the levels of motivation each group of participant's experiences and if there is any significant change in motivation. By measuring students' levels of confidence in engineering over the course of the semesters, changes in perspective of engineering can be tied to the academic work done by the student during the semester. Comparing participants' responses from ECE 466 to participants' responses from the ECE 403 and 401/5 groups for the POS responses and the ECES responses should indicate the role of research in learning.

7.1 Study Habits of Students

The study habits of participants were investigated through data collected in the PFEAS to see whether the participants' motivation during the semester was impacted by

the courses they were enrolled in. Comparing the mean responses to each of the groups for the questions in the PFEAS on study habits reveals differences and trends between the groups as the semester progressed. While all participating groups indicated that they felt confident in their current study habits, they all also indicated that they needed to spend more time studying. Participants from the ECE 403 groups showed a decrease in the mean response (question 46), while the other groups showed an increase in the mean response from pre- to post-PFEAS. This could be explained by fact that the ECE 403 group, consisting entirely of seniors who were approaching the end of their academic careers and having complete senior project presentations, realized decreased workloads during the final weeks of college. Juniors in ECE 401/5 realize that projects, labs, and exams are coming up near the end of the semester and must take on a larger workload. This is also shown in the responses to question 67, where participants in ECE 403 indicated that they would not give themselves an A on their study habits, while participants in ECE 401/5 had a stronger indication that they would give themselves an A on their study habits.

When the three groups were asked about their preferences on working in a group versus working alone, participants from ECE 466 indicated that they preference to independent work and study, while ECE 403 and ECE 401/5 preferred to work in groups. This result could stem from the fact that students in ECE 403 and 401/5 rely on collaboration with their partners, classmates and professors to complete a three-semester long project. Several of the participants from the ECE 466 group have been previously conducted research in their related fields and have worked independently on projects outside of the course.

7.2 Major Identity and Confidence

The questions in the PFEAS that ask students to respond to several statements about their levels of confidence with engineering and how they identify as an engineer reveal several correlations. Participants from all groups gave indications that they are confident in their ability and desire to succeed in engineering, Figure 5 in both the pre- and post- PFEAS responses. Participants also indicated a consistent decrease in their perspectives on how rewarding engineering is, Figure 7, from pre- to post- PFEAS. Participants in ECE 403 responded with the lowest levels of the three groups for these four question on how rewarding engineering is. On 3 of the 4 questions, responses from the University of Maine participants gave lower mean responses than the freshman civil engineering students from The Citadel [9]. Also, students' response from The Citadel study showed increased means as the semester progressed, while participants at the University of Maine decreased mean responses.

Participants also indicated higher levels of dissatisfaction with engineering as the semester progresses, Figure 8. Participants in ECE 403 have the highest levels of dissatisfaction with their major of the three groups. Seniors experiencing higher levels of dissatisfaction may be due to the approaching date of graduation for the seniors and are ready to enter to workforce. Participants from both ECE 403 and ECE 401/5 expressed decreased levels of desire to graduate in engineering and how rewarding they feel engineering signals that the students' motivation decreases as the semester progresses, and how they identify with their major also decreases. Many of the groups showed higher mean responses than those of freshman civil engineers [9], which were compared to the

results of this study. This could be attributed to the fact that the participants from the referenced study were freshmen in civil engineering. This increased dissatisfaction among University of Maine students could also indicate that as students' progress further as engineering students, their levels of dissatisfaction increase.

7.3 Research in Learning

Responses from the ECES indicates that students reported that they retain more from project/research based assignments, over highly structured assignments, like homework, reading and exams. This result suggests that research and projects yield higher retention and motivation in students, which is consistent with a recent study on student motivation and performance for electrical engineers, where a positive correlation between students with research experience and higher cumulative GPAs was found [10]. Another study conducted in 2016 demonstrated that students who work to create real-world learning projects focused on key concepts from lower level courses retain the information better when compared to knowledge retained from exams took during the semester [11].

Looking at the first 10 questions of the POS, participants from ECE 466 consistently had higher mean responses than participants from ECE 403 or ECE 401/5. This is likely because ECE 466 asks students to research their field for the various subjects covered in the lab and the course project. Students in ECE 403 and 401/5 indicated much lower levels of enjoyment, ownership, and confidence in their projects. Projects selected in ECE 401/5 are often projects that are modifications or minor

improvements to preexisting projects or designs and thus do not push students to do further research into the field related to their project.

To promote increased student motivation and enjoyment of the senior design sequence, students could be exposed to research as early as their freshman year. Students who have been exposed to course-based undergraduate research experiences, CUREs, in their freshman year are significantly more likely to graduate with a STEM degree than students not exposed to CUREs [12].

8 Future Work

After collecting the data from the three surveys for this study, there were several more points that should be explored in the future as an extension of this study. First would be an in-depth study comparing retention levels, student enjoyment, and confidence in engineering between upper level electives that have a course project and required lab courses offered through the ECE department.

Another future study would be to continue tracking individual students' motivation over the course of their undergraduate careers. The modified version of the ABET Survey sequence [7] in which questions apply specifically to the University of Maine's Engineering program, would be used to gauge student motivation and perspectives over the course of their four-year undergraduate career in the ECE department.

A further investigation of the impact of research on students' motivation, confidence and opinions, with an additional focus on students who were exposed to research earlier on in their academic career. Utilizing a modified version of the POS

(replacing “research” with “project”) this study would aim to compare students taught through traditional laboratory based courses and students taught through research based courses.

9 Conclusion

The levels of student motivation, confidence and identity as engineers in the upper-class of the ECE department were measured using the Pittsburgh Freshman Engineering Aptitude Survey, Project Ownership Survey, and the 2017 Electrical and Computer Engineering Survey. This study found that students report that they retain more from project and research based assignments over more structured assignments (exams, homework, etc.). Furthermore, the results of this study suggest that when students are exposed to research prior to selecting a project, they are more likely to claim more ownership over the project and have levels of higher motivation to work on the project. Students who are enrolled in the Senior Project Design Course Sequence, (ECE 401/2/3/5/6), show a higher preference toward collaborative work than those in the elective based course, ECE 466. Also, students in the Senior Project Design Course Sequence conveyed lower levels of ownership over their complete projects than students in ECE 466. Upper-class students enrolled in electrical and computer engineering at the University of Maine consistently reported decreasing levels of satisfaction with engineering as the semester progressed and showed higher levels of dissatisfaction with engineering than freshman civil engineering students at another institution [9]. Additional studies are needed to further test the conclusions drawn in this study.

The results of this study suggest that research based courses should be offered earlier in a student's academic career to increase students' confidence and motivation in engineering. The level of dissatisfaction for upper-class engineers at the University of Maine being higher than freshman engineers from other universities is concerning. Further studies should be conducted to see how best to increase student motivation and confidence within the ECE department at the University of Maine.

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11 Appendix I: Consent forms

GENERAL CONSENT FORM

You are invited to participate in a research project being conducted by Thomas Leighton, an undergraduate student in the Department of Engineering at the University of Maine and Mauricio Pereira da Cunha a faculty member in the Department of Engineering at the University of Maine. The purpose of the research is gauge the relationship between students identifying with their major and the ability to have freedom in the choice of their research topics. You must be at least 18 years of age to participate.

What Will You Be Asked to Do?

You are being asked to give the investigators of this study access to collect and use data about
your performance over the duration of this course. You will be asked to complete a 15-minute survey at the beginning and end of the course, as well as a 5-minute survey at the completion of major course projects. The information gathered will be only be used for the purpose of this study. Below are some questions similar to ones you'll be asked in the survey.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel I know what an engineer does.	○ 1	○ 2	○ 3	○ 4	○ 5
Studying in a group is better than studying by myself.	○ 1	○ 2	○ 3	○ 4	○ 5

Risks

The participation risks of this study are no greater than the risks in everyday class experience.
class experience.

Benefits

While this study may have no direct benefit to you, this research may help us learn more about what motivates students to perform better in classes and how to encourage students to identify more with their major. Participation in this study will have no impact on your grade for the course.

Confidentiality

You will be asked to submit identifying information during this study. All data collected that is linked to your name will be stored with a 10-digit number in place of your name. The key linking participant's names to the 10-digit number will be kept in a password protected spreadsheet and will be stored using software that provides additional security. The key will be destroyed upon the completion of the study, 5/6/2017. All data collected will be kept indefinitely. Your individual privacy will be maintained in all published material resulting from this study as well as in presentations of study results to professional audiences.

Voluntary

Participation in this study is voluntary. If you choose to take part in this study, you may stop at any time. You may skip any questions you do not wish to answer on any of the pre/post surveys and the project surveys. Participation in this study will have no impact on your grade for the course.

Contact Information

If you have any questions about this study, please contact me at thomas.leighton@maine.edu. You may also reach the faculty advisor on this study at mdacunha@maine.edu. If you have any questions about your rights as a research participant, please contact Gayle Jones, Assistant to the University of Maine's Protection of Human Subjects Review Board, at 581-1498 (or e-mail gayle.jones@umit.maine.edu).

Your signature below indicates that you have read the above information and agree to participate. You will receive a copy of this form.

_____ _____

Signature Date

ECE 466 STUDY CONSENT FORM

You are invited to participate in a research project being conducted by Thomas Leighton, an undergraduate student in the Department of Engineering at the University of Maine and Mauricio Pereira da Cunha a faculty member in the Department of Engineering at the University of Maine. The purpose of the research is gauge the relationship between students identifying with their major and the ability to have freedom in the choice of their research topics. You must be at least 18 years of age to participate.

What Will You Be Asked to Do?

You are being asked to give the investigators of this study access to collect and use data about

your performance over the duration of this course. You will be asked to complete a 15-minute survey at the beginning and end of the course, as well as a 5-minute survey at the completion of major course projects. These data could include: your responses to surveys and laboratory reports, quizzes and exams. The information gathered will be only be used for the purpose of this study. Below are some questions similar to ones you'll be asked in the survey.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel I know what an engineer does.	○ 1	○ 2	○ 3	○ 4	○ 5
Studying in a group is better than studying by myself.	○ 1	○ 2	○ 3	○ 4	○ 5

Risks

The participation risks of this study are no greater than the risks in everyday class experience.

class experience.

Benefits

- While this study may have no direct benefit to you, this research may help us learn more about what motivates students to perform better in classes and how to encourage students to identify more with their major.
- Provide information on how to better improve ECE 466 for future classes.

Confidentiality

You will be asked to submit identifying information during this study. All data collected that is linked to your name will be stored with a 10-digit number in place of your name. The key linking participant's names to the 10-digit number will be kept in a password protected spreadsheet and will be stored using software that provides additional security. The key will be destroyed upon the completion of the study, 5/6/2017. All data collected will be kept indefinitely. Your individual privacy will be maintained in all published material resulting from this study as well as in presentations of study results to professional audiences.

Voluntary

Participation in this study is voluntary. If you choose to take part in this study, you may stop at any time. You may skip any questions you do not wish to answer on any of the pre/post surveys and the project surveys. Participation in this study will have no impact on your grade for the course.

Contact Information

If you have any questions about this study, please contact me at thomas.leighton@maine.edu. You may also reach the faculty advisor on this study at mdacunha@maine.edu. If you have any questions about your rights as a research participant, please contact Gayle Jones, Assistant to the University of Maine's Protection of Human Subjects Review Board, at 581-1498 (or e-mail gayle.jones@umit.maine.edu).

Your signature below indicates that you have read the above information and agree to participate. You will receive a copy of this form.

_____ _____

Signature Date

12 Appendix II: Surveys [7] [8]

Engineering Student Attitudes Survey

This is a survey to elicit engineering students opinions and feelings about engineering. Please do not spend more than 15 minutes to complete the questionnaire, so work as quickly as you can. Complete the following information as instructed.

1. Why did you choose to become an engineering major?

For each statement, please fill in the number that corresponds to how strongly you disagree or agree with the statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
2. I expect that engineering will be a rewarding career.	O 1	O 2	O 3	O 4	O 5
3. I expect that studying engineering will be rewarding.	O 1	O 2	O 3	O 4	O 5
4. The advantages of studying engineering outweigh the disadvantages.	O 1	O 2	O 3	O 4	O 5
5. I don't care for this career.	O 1	O 2	O 3	O 4	O 5
6. The future benefits of studying engineering are worth the effort.	O 1	O 2	O 3	O 4	O 5
7. I can think of several other majors that would be more rewarding than engineering.	O 1	O 2	O 3	O 4	O 5
8. I have no desire to change to another major (ex. biology, English, chemistry, art, history, etc.).	O 1	O 2	O 3	O 4	O 5
9. The rewards of getting an engineering degree are not worth the effort.	O 1	O 2	O 3	O 4	O 5
10. From what I know, engineering is boring.	O 1	O 2	O 3	O 4	O 5
11. Engineers are well paid.	O 1	O 2	O 3	O 4	O 5
12. Engineers contribute more to making the world a better place than people in most other occupations.	O 1	O 2	O 3	O 4	O 5
13. Engineers are innovative.	O 1	O 2	O 3	O 4	O 5
14. I enjoy the subjects of science and mathematics the most.	O 1	O 2	O 3	O 4	O 5
15. I will have no problem finding a job when I have obtained an engineering degree.	O 1	O 2	O 3	O 4	O 5
16. Engineering is an exact science.	O 1	O 2	O 3	O 4	O 5
17. My parent(s) are making me study engineering.	O 1	O 2	O 3	O 4	O 5
18. Engineering is an occupation that is respected by other people.	O 1	O 2	O 3	O 4	O 5
19. I like the professionalism that goes with being an engineer.	O 1	O 2	O 3	O 4	O 5
20. I enjoy taking liberal arts courses more than math and science courses.	O 1	O 2	O 3	O 4	O 5
21. Engineering is more concerned with improving the welfare of society than most other professions.	O 1	O 2	O 3	O 4	O 5
22. I am studying engineering because it will provide me with a lot of money; and I cannot do this in other professions.	O 1	O 2	O 3	O 4	O 5
23. Engineers have contributed greatly to fixing problems in the world.	O 1	O 2	O 3	O 4	O 5
24. An engineering degree will guarantee me a job when I graduate.	O 1	O 2	O 3	O 4	O 5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
25. My parent(s) want me to be an engineer.	O 1	O 2	O 3	O 4	O 5
26. Engineers are creative.	O 1	O 2	O 3	O 4	O 5
27. Engineering involves finding precise answers to problems.	O 1	O 2	O 3	O 4	O 5
28. I am studying engineering because I enjoy figuring out how things work.	O 1	O 2	O 3	O 4	O 5
29. Technology plays an important role in solving society's problems.	O 1	O 2	O 3	O 4	O 5
30. A teacher or counselor suggested that I should become an engineer.	O 1	O 2	O 3	O 4	O 5
31. I want a career that will help others (and engineers help others.)	O 1	O 2	O 3	O 4	O 5
32. Engineers need good communication and writing skills.	O 1	O 2	O 3	O 4	O 5
33. Engineers need to be able to analyze complex data.	O 1	O 2	O 3	O 4	O 5
34. Anyone who starts off as an engineering major has the ability to graduate in engineering.	O 1	O 2	O 3	O 4	O 5
35. Engineers must understand contemporary issues.	O 1	O 2	O 3	O 4	O 5

For the following subjects and skills, please fill in the number corresponding to the response that best describes how confident you are of your abilities in the subject or skill.

	Not Strongly Confident	Not Confident	Neutral	Confident	Strongly Confident
36. Chemistry	O 1	O 2	O 3	O 4	O 5
37. Physics	O 1	O 2	O 3	O 4	O 5
38. Calculus	O 1	O 2	O 3	O 4	O 5
39. Engineering	O 1	O 2	O 3	O 4	O 5
40. Writing	O 1	O 2	O 3	O 4	O 5
41. Speaking	O 1	O 2	O 3	O 4	O 5
42. Computer Skills	O 1	O 2	O 3	O 4	O 5

For the following statements about studying, working in groups and personal abilities, please fill in the number corresponding to the response that best describes how strongly you disagree or agree with the statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
43. I feel I know what an engineer does.	O 1	O 2	O 3	O 4	O 5
44. Studying in a group is better than studying by myself.	O 1	O 2	O 3	O 4	O 5
45. Creative thinking is one of my strengths.	O 1	O 2	O 3	O 4	O 5
46. I need to spend more time studying than I currently do.	O 1	O 2	O 3	O 4	O 5
47. I have strong problem solving skills.	O 1	O 2	O 3	O 4	O 5
48. Most of my friends that I 'hang-out' with are studying engineering.	O 1	O 2	O 3	O 4	O 5
49. I feel confident in my ability to succeed in engineering.	O 1	O 2	O 3	O 4	O 5
50. I prefer studying/working alone.	O 1	O 2	O 3	O 4	O 5

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
51. I am good at designing things.	O 1	O 2	O 3	O 4	O 5
52. In the past, I have not enjoyed working in assigned groups.	O 1	O 2	O 3	O 4	O 5
53. I am confident about my current study habits or routine.	O 1	O 2	O 3	O 4	O 5
54. I consider myself mechanically inclined.	O 1	O 2	O 3	O 4	O 5
55. I consider myself technically inclined.	O 1	O 2	O 3	O 4	O 5
56. I enjoy solving open-ended problems.	O 1	O 2	O 3	O 4	O 5
57. I enjoy problems that can be solved in different ways.	O 1	O 2	O 3	O 4	O 5
58. I am confident that I will succeed in engineering study.	O 1	O 2	O 3	O 4	O 5
59. I have a tendency to sabotage my success.	O 1	O 2	O 3	O 4	O 5
60. When I experience failures, it is usually someone else's fault.	O 1	O 2	O 3	O 4	O 5
61. I prefer to solve difficulties on my own, without seeking help from others.	O 1	O 2	O 3	O 4	O 5
62. There are things about myself that I would like to change	O 1	O 2	O 3	O 4	O 5
63. I tend to procrastinate, putting off the things I need to do	O 1	O 2	O 3	O 4	O 5
64. I keep up in my classes by mastering the material presented in the last class meeting before the next class meeting.	O 1	O 2	O 3	O 4	O 5
65. I tend to avoid doing things that I don't enjoy.	O 1	O 2	O 3	O 4	O 5
66. I recognize the importance of goal setting, and I have clear academic goals.	O 1	O 2	O 3	O 4	O 5
67. I would give myself an A+ on the amount of time and energy I devote to my studies.	O 1	O 2	O 3	O 4	O 5
68. I am certain that I want to graduate in engineering.	O 1	O 2	O 3	O 4	O 5
69. I am certain that I will be able to graduate in engineering.	O 1	O 2	O 3	O 4	O 5
70. I plan to join a student engineering organization.	O 1	O 2	O 3	O 4	O 5

Name:	
Major:	
Cumulative GPA:	None yet 0.00-1.99 2.00-2.49 2.50-2.99 3.00-3.49 3.50-4.00 ☐ ☐ ☐ ☐ ☐ ☐
Year in School:	Other FR SO JR SR GRAD ☐ ☐ ☐ ☐ ☐ ☐
What is your Sex?	M ☐ F ☐

Project Ownership Survey

Name:	
Major:	
Cumulative GPA:	None yet □ 0.00-1.99 □ 2.00-2.49 □ 2.50-2.99 □ 3.00-3.49 □ 3.50-4.00 □
Year in School:	Other □ FR □ SO □ JR □ SR □ GRAD □
Gender	M □ F □

	Strongly Disagree	**Disagree**	**Neither Agree nor disagree**	**Agree**	**Strongly Agree**
My research will help to solve a problem in the world.	□	□	□	□	□
My findings were important to the scientific community.	□	□	□	□	□
I faced challenges that I managed to overcome in completing my research project.	□	□	□	□	□
I was responsible for the outcomes of my research.	□	□	□	□	□
The findings of my research project gave me a sense of personal achievement.	□	□	□	□	□
I had a personal reason for choosing the research project I worked on.	□	□	□	□	□
The research question I worked on was important to me.	□	□	□	□	□
In conducting my research project, I actively sought advice and assistance.	□	□	□	□	□
My research project was interesting.	□	□	□	□	□
My research project was exciting.	□	□	□	□	□
	Very	Slightly	Moderate	Considerably	Very

	slightly				strongly
To what extent does the word *delighted* describe your experience of the laboratory course?	□	□	□	□	□
To what extent does the word *happy* describe your experience of the laboratory course?	□	□	□	□	□
To what extent does the word *joyful* describe your experience of the laboratory course?	□	□	□	□	□
To what extent does the word *astonished* describe your experience of the laboratory course?	□	□	□	□	□
To what extent does the word *surprised* describe your experience of the laboratory course?	□	□	□	□	□
To what extent does the word *amazed* describe your experience of the laboratory course?	□	□	□	□	□

2017 Electrical and Computer Engineering Survey

Name:	
Major:	
Cumulative GPA:	None yet □ 0.00-1.99 □ 2.00-2.49 □ 2.50-2.99 □ 3.00-3.49 □ 3.50-4.00 □
Year in School:	Other □ FR □ SO □ JR □ SR □ GRAD □
Gender	M □ F □

1) If you are currently taking any of the following courses, please indicate the average time you spend on that course each week.

	N/A	0 to	2 to	4 to	6 to	8 to	10+hrs

		2hrs	4hrs	6hrs	8hrs	10hrs	
ECE 486	□	□	□	□	□	□	□
ECE 403	□	□	□	□	□	□	□
ECE 343	□	□	□	□	□	□	□
ECE 414	□	□	□	□	□	□	□
ECE 401/5	□	□	□	□	□	□	□
ECE 477	□	□	□	□	□	□	□
ECE 331	□	□	□	□	□	□	□
COS 431	□	□	□	□	□	□	□
ECE 478	□	□	□	□	□	□	□
ECE 444	□	□	□	□	□	□	□

2) Do you live off campus? Yes □ No □
3) If yes, how long is your commute in one direction in minutes.
   Less than 15 □ 15 to 30 □ 30 to 45 □ 45 to 60 □ More than 60 □
4) If you are involved in any organizations on campus, please indicate the combined weekly time commitment for all of the groups you are involved with.

N/A	0 to 2hrs	2 to 4hrs	4 to 6hrs	6 to 8hrs	8 to 10hrs	10+hrs
□	□	□	□	□	□	□

5) Please indicate how many days a week you get more than 6 hours of sleep per night on average.

0	1	2	3	4	5	6	7
□	□	□	□	□	□	□	□

6) Please indicate how many times a month you get more than 3 hours of sleep in a 24-hour day.

0 to 1	2 to 3	4 to 6	7 to 10	10 to 12	More than 12
□	□	□	□	□	□

7) If you have a job while attending college, please indicate how many hours a week you work on average.

N/A	0 to 5hrs	5 to 10hrs	10 to 15hrs	15 to 20hrs	20+hrs
□	□	□	□	□	□

8) If you take any of the following courses, what is your expected GPA?

	N/A	0.00-1.99	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00
ECE 486	□	□	□	□	□	□
ECE 403	□	□	□	□	□	□
ECE 343	□	□	□	□	□	□
ECE 414	□	□	□	□	□	□
ECE 401/5	□	□	□	□	□	□
ECE 477	□	□	□	□	□	□

ECE 331	□	□	□	□	□	□
COS 431	□	□	□	□	□	□
ECE 478	□	□	□	□	□	□
ECE 444	□	□	□	□	□	□

9) Rank the following course activities based on your personal retention of knowledge and preference, (1 being leads to little retention/dislike and 5 being retained a significant amount and enjoy)

	1	2	3	4	5
Lecture	□	□	□	□	□
Assigned reading	□	□	□	□	□
Homework (weekly)	□	□	□	□	□
Homework (daily)	□	□	□	□	□
Labs	□	□	□	□	□
Projects (assigned topic)	□	□	□	□	□
Projects (Student chosen topic)	□	□	□	□	□
Exams	□	□	□	□	□
Recitation	□	□	□	□	□
Individual study	□	□	□	□	□

10) If you have taken any of the following courses, indicate which coursed you have gained and retained the most from.

	N/A	Little to none	Some	A moderate amount	A decent amount	A Significant Amount
ECE 486	□	□	□	□	□	□
ECE 403	□	□	□	□	□	□
ECE 343	□	□	□	□	□	□
ECE 414	□	□	□	□	□	□
ECE 401/5	□	□	□	□	□	□
ECE 477	□	□	□	□	□	□
ECE 331	□	□	□	□	□	□
COS 431	□	□	□	□	□	□
ECE 478	□	□	□	□	□	□
ECE 444	□	□	□	□	□	□

13 Appendix III: Survey Reponses

Table 5: Pittsburgh Freshman Engineering Attitudes Survey results[1]

	FPEAS(pre)		FPEAS(post)		FPEAS Difference(pre to post)	
Q	MEAN	SD	MEAN	SD	ΔMEAN	ΔSD
2	4.563	0.501	4.289	0.732	0.273	-0.230
3	4.333	0.694	4.000	0.900	0.333	-0.206
4	4.333	0.630	4.132	0.704	0.202	-0.074
5	1.604	0.574	1.868	0.991	-0.264	-0.417
6	4.521	0.545	4.237	0.634	0.284	-0.089
7	2.292	0.922	2.421	1.004	-0.129	-0.082
8	4.146	0.989	4.000	1.115	0.146	-0.126
9	1.771	0.805	2.026	0.854	-0.255	-0.049
10	1.708	0.874	1.842	0.855	-0.134	0.019
11	4.438	0.616	4.342	0.534	0.095	0.082
12	3.646	0.887	3.526	0.922	0.120	-0.035
13	4.042	0.651	4.079	0.712	-0.037	-0.061
14	4.292	0.617	4.105	0.649	0.186	-0.031
15	3.896	0.973	3.816	1.036	0.080	-0.063
16	2.667	1.078	2.500	0.952	0.167	0.127
17	1.396	0.536	1.500	0.688	-0.104	-0.152
18	4.250	0.565	4.132	0.529	0.118	0.036
19	3.729	1.026	3.737	0.828	-0.008	0.198
20	1.688	0.854	1.816	0.926	-0.128	-0.071
21	3.083	0.767	3.132	0.991	-0.048	-0.224
22	2.917	0.942	3.263	0.978	-0.346	-0.036
23	4.229	0.751	4.211	0.577	0.019	0.174
24	3.396	1.026	3.474	1.059	-0.078	-0.033
25	3.396	0.818	3.395	0.855	0.001	-0.037
26	3.896	0.692	3.947	0.733	-0.052	-0.042
27	3.167	1.078	3.053	0.985	0.114	0.094
28	4.354	0.601	4.237	0.675	0.117	-0.074
29	4.396	0.610	4.211	0.777	0.185	-0.167
30	2.917	1.048	3.132	1.018	-0.215	0.030
31	3.771	0.905	3.842	0.754	-0.071	0.151
32	4.438	0.741	4.289	0.565	0.148	0.176
33	4.417	0.577	4.189	0.660	0.227	-0.083
34	2.625	1.231	2.243	1.116	0.382	0.116
35	3.851	0.751	3.711	0.867	0.141	-0.116
36	2.875	0.981	3.026	1.000	-0.151	-0.018
37	4.104	0.778	4.000	0.838	0.104	-0.060
38	4.375	0.733	4.237	0.714	0.138	0.019
39	4.271	0.707	4.263	0.760	0.008	-0.053
40	3.833	0.907	3.895	1.085	-0.061	-0.178

[1]This table shows the mean response and standard deviation, SD, of the first PFEAS, column 2, and the second PFEAS, column 3 for all of the Likert scale questions, column 1. The 4th column displays the difference in mean and standard deviation from the first to the second PFEAS.

Table 5: Pittsburgh Freshman Engineering Attitudes Survey results (Cont.)

	FPEAS 1		FPEAS 2		FPEAS Difference(1-2)	
Q	MEAN	SD	MEAN	SD	ΔMEAN	ΔSD
41	3.479	0.989	3.605	1.028	-0.126	-0.039
42	4.500	0.619	4.289	0.898	0.211	-0.279
43	3.979	0.635	3.974	0.716	0.005	-0.081
44	3.729	1.005	3.658	0.966	0.071	0.039
45	3.729	0.792	3.684	1.042	0.045	-0.251
46	3.583	1.069	3.684	1.042	-0.101	0.026
47	4.146	0.684	4.105	0.798	0.041	-0.114
48	3.521	1.148	3.658	1.236	-0.137	-0.088
49	4.063	0.810	4.053	0.837	0.010	-0.027
50	3.063	1.080	3.184	1.062	-0.122	0.018
51	3.681	0.629	3.711	0.867	-0.030	-0.238
52	3.404	0.925	3.526	0.830	-0.122	0.095
53	3.404	0.925	3.526	0.922	-0.122	0.002
54	3.617	0.795	3.658	0.994	-0.041	-0.198
55	4.064	0.604	4.105	0.831	-0.041	-0.227
56	3.702	0.805	3.605	0.946	0.097	-0.140
57	4.064	0.673	3.974	0.788	0.090	-0.115
58	4.087	0.694	4.158	0.789	-0.071	-0.096
59	2.638	1.031	2.632	1.051	0.007	-0.020
60	2.021	0.737	1.868	0.704	0.153	0.033
61	3.064	1.030	3.053	1.038	0.011	-0.008
62	3.915	0.996	3.868	0.963	0.046	0.033
63	3.723	1.057	3.421	1.200	0.302	-0.143
64	2.723	0.743	2.395	1.001	0.329	-0.258
65	3.787	0.750	3.632	1.025	0.156	-0.275
66	3.596	0.798	3.757	0.830	-0.161	-0.032
67	3.128	1.055	3.250	1.180	-0.122	-0.125
68	4.596	0.538	4.216	1.031	0.380	-0.493
69	4.404	0.614	4.486	0.607	-0.082	0.007
70	3.191	1.014	3.027	0.957	0.164	0.057

Table 6: FPEAS Responses by Class[2]

Q	DIFFERENCE(pre-post)				DIFFERENCE(ECE 403-ECE 401/5)			
	ECE 403 MEAN	ECE 401/405 MEAN	ECE 403 SD	ECE 401/405 SD	MEAN	SD	MEAN	SD
2	0.209	0.286	-0.193	-0.051	-0.305	0.040	-0.229	0.182
3	0.332	0.214	-0.432	0.171	-0.247	-0.369	-0.364	0.234
4	0.182	0.143	0.027	0.065	-0.247	-0.088	-0.286	-0.049
5	-0.373	-0.048	-0.470	-0.154	0.203	-0.051	0.529	0.265
6	0.173	0.286	-0.090	-0.051	-0.442	0.088	-0.329	0.127
7	-0.327	0.143	-0.219	0.203	-0.156	-0.201	0.314	0.221
8	0.050	0.214	-0.211	0.017	-0.143	0.009	0.021	0.237
9	-0.245	-0.310	-0.172	-0.290	0.478	0.210	0.414	0.093
10	-0.077	-0.024	0.015	0.116	0.011	-0.406	0.064	-0.304
11	0.114	0.143	0.031	0.084	-0.208	-0.017	-0.179	0.037
12	-0.105	0.643	-0.217	0.230	-0.169	-0.551	0.579	-0.104
13	-0.091	0.071	-0.185	0.039	-0.234	-0.044	-0.071	0.179
14	0.091	0.143	-0.036	-0.050	-0.338	-0.150	-0.286	-0.164
15	-0.023	0.071	0.084	-0.288	-0.416	0.082	-0.321	-0.290
16	0.005	0.524	0.145	0.252	-0.355	0.065	0.164	0.173
17	-0.050	-0.071	-0.089	-0.170	0.214	0.135	0.193	0.053
18	0.045	0.214	-0.187	0.172	-0.383	-0.223	-0.214	0.136
19	-0.009	-0.071	0.300	0.032	-0.123	0.047	-0.186	-0.221
20	0.118	-0.167	0.174	-0.028	0.199	0.042	-0.086	-0.160
21	-0.432	0.524	-0.118	-0.369	-0.420	0.032	0.536	-0.218
22	-0.441	-0.167	0.144	-0.183	0.147	0.130	0.421	-0.197
23	-0.145	0.214	0.233	0.019	-0.474	0.188	-0.114	-0.026
24	-0.105	-0.214	0.006	-0.125	-0.526	0.120	-0.636	-0.011
25	0.055	-0.119	-0.020	-0.020	0.074	0.060	-0.100	0.061
26	-0.223	0.095	-0.123	-0.073	-0.225	0.113	0.093	0.163
27	-0.232	0.571	0.082	0.006	-0.610	0.311	0.193	0.235
28	0.127	0.048	-0.106	-0.002	-0.249	0.100	-0.329	0.205
29	0.082	0.190	-0.200	-0.016	-0.437	0.091	-0.329	0.275
30	-0.200	-0.024	-0.022	0.020	-0.048	-0.288	0.129	-0.247
31	-0.059	-0.214	0.109	0.234	-0.266	-0.110	-0.421	0.015
32	0.123	0.167	0.348	0.015	-0.251	0.423	-0.207	0.090
33	0.223	0.310	-0.136	-0.067	-0.251	0.039	-0.164	0.107
34	0.388	0.119	0.076	-0.022	-0.074	-0.060	-0.342	-0.157
35	-0.031	0.095	-0.144	0.142	-0.333	-0.136	-0.207	0.150

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[2]This table shows the difference in the mean response for each Likert scale question, column 1, in the PFEAS pre to post by the participants from ECE 403 and ECE401/5, column 2. The change in standard deviation, SD, from pre to post PFEAS for each group is shown in column 3. Columns 4 and 5 display the difference in mean response and SD between the ECE 403 participants and ECE 401/5 participants for the pre and post PFEAS respectively

Table 6: FPEAS Responses by Class (Cont.)

Q	DIFFERENCE(1-2)				DIFFERENCE(SR-JR)			
	ECE 403 MEAN	ECE 401/405 MEAN	ECE 403 SD	ECE 401/405 SD	MEAN1	SD1	MEAN2	SD2
36	-0.318	-0.071	-0.031	0.219	-0.318	0.046	-0.071	0.296
37	0.091	0.095	0.122	0.046	-0.004	-0.147	0.000	-0.223
38	-0.159	0.190	0.367	-0.016	-0.528	0.314	-0.179	-0.069
39	-0.118	0.024	0.263	0.036	-0.199	0.064	-0.057	-0.163
40	-0.036	-0.214	-0.352	0.048	0.149	-0.629	-0.029	-0.229
41	-0.095	-0.286	-0.029	0.094	-0.117	-0.263	-0.307	-0.140
42	0.145	0.167	-0.158	-0.143	0.022	-0.006	0.043	0.009
43	-0.136	0.048	0.143	0.061	-0.184	-0.272	0.000	-0.355
44	0.218	-0.119	0.204	0.081	0.009	-0.120	-0.329	-0.243
45	0.023	0.048	0.062	-0.369	0.154	-0.362	0.179	-0.792
46	0.377	-0.476	-0.051	0.058	0.203	-0.284	-0.650	-0.176
47	0.041	-0.048	0.079	0.089	-0.147	-0.017	-0.236	-0.006
48	-0.205	-0.357	0.061	-0.080	-0.026	-0.336	-0.179	-0.477
49	-0.195	0.095	0.066	0.159	-0.141	-0.291	0.150	-0.197
50	-0.382	0.262	-0.149	0.253	-0.372	-0.343	0.271	0.059
51	-0.159	0.136	-0.048	-0.243	-0.259	-0.080	0.036	-0.275
52	-0.036	-0.221	0.027	0.188	0.014	-0.192	-0.171	-0.031
53	-0.318	-0.021	0.034	0.112	-0.368	-0.255	-0.071	-0.177
54	-0.109	-0.114	-0.245	0.057	-0.009	-0.148	-0.014	0.153
55	-0.205	0.100	0.025	-0.144	-0.055	-0.065	0.250	-0.234
56	-0.018	0.171	0.237	-0.336	0.082	0.213	0.271	-0.359
57	0.055	-0.064	0.170	-0.112	-0.195	0.135	-0.314	-0.147
58	-0.291	-0.004	0.003	0.088	-0.301	-0.261	-0.014	-0.176
59	0.223	-0.043	0.207	-0.210	0.173	0.212	-0.093	-0.206
60	0.086	0.164	0.024	0.126	0.186	-0.115	0.264	-0.013
61	0.005	-0.114	-0.043	0.159	-0.145	-0.366	-0.264	-0.164
62	0.205	-0.129	-0.069	0.188	0.155	-0.155	-0.179	0.103
63	0.236	0.450	-0.183	-0.093	-0.314	0.050	-0.100	0.139
64	0.377	0.336	-0.173	-0.288	0.177	0.098	0.136	-0.017
65	0.173	0.350	-0.069	-0.615	-0.077	0.081	0.100	-0.465
66	-0.286	-0.042	-0.086	-0.042	-0.286	-0.086	-0.042	-0.042
67	-0.232	-0.167	-0.188	0.074	-0.432	-0.112	-0.367	0.150
68	0.600	0.188	-0.522	-0.388	-0.150	0.108	-0.562	0.242
69	-0.132	-0.138	0.057	0.020	-0.082	-0.113	-0.088	-0.150
70	-0.073	0.219	-0.065	-0.089	-0.723	-0.515	-0.431	-0.539

Table 7: Project Ownership Survey Results[3]

	Question	MEAN	SD
1	My research will help to solve a problem in the world.	3.351	1.086
2	My findings were important to the scientific community.	2.973	0.957
3	I faced challenges that I managed to overcome in completing my research project.	3.676	0.747
4	I was responsible for the outcomes of my research.	3.757	0.760
5	The findings of my research project gave me a sense of personal achievement.	3.811	0.739
6	I had a personal reason for choosing the research project I worked on.	3.270	1.045
7	The research question I worked on was important to me.	3.324	1.107
8	In conducting my research project, I actively sought advice and assistance.	3.541	0.836
9	My research project was interesting.	3.865	0.948
10	My research project was exciting.	3.757	1.011
11	To what extent does the word delighted describe your experience of the laboratory course?	2.595	1.117
12	To what extent does the word happy describe your experience of the laboratory course?	2.757	1.164
13	To what extent does the word joyful describe your experience of the laboratory course?	2.486	1.121
14	To what extent does the word astonished describe your experience of the laboratory course?	2.324	1.056
15	To what extent does the word surprised describe your experience of the laboratory course?	2.405	0.927
16	To what extent does the word amazed describe your experience of the laboratory course?	2.297	1.175

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[3]This table show the mean responses and standard deviation, SD, by the all surey participants to the POS Likhert scale questions listed.

Table 8: 2017 Electrical and Computer Engineering Survey[4]

	QUESTION	MEAN	SD	N
1	ECE 486	3.750	1.342	16
	ECE 403	1.818	0.751	11
	ECE 343	3.778	1.093	9
	ECE 414	2.000	0.866	9
	ECE 401/5	2.308	1.182	13
	ECE 477	2.727	1.191	11
	ECE 331	3.600	1.817	5
	COS 431	NA	NA	0
	ECE 478	NA	NA	0
	ECE 444	3.500	0.707	2
2		0.654	0.485	26
3		1.222	0.428	18
4		2.938	1.914	16
5		4.560	2.347	25
7		2.800	1.821	15
8	ECE 486	3.333	1.073	12
	ECE 403	4.000	0.535	8
	ECE 343	3.167	0.983	6
	ECE 414	3.429	1.134	7
	ECE 401/5	4.300	0.483	10
	ECE 477	5.000	0.000	6
	ECE 331	4.200	0.837	5
	COS 431	NA	NA	0
	ECE 478	NA	NA	0
	ECE 444	NA	NA	0
9	Lecture	2.950	1.234	20
	Assigned reading	1.737	0.933	19
	Homework (weekly)	3.400	0.995	20
	Homework (daily)	2.200	1.056	20
	Labs	3.600	0.598	20
	Projects (assigned topic)	3.450	0.945	20
	Projects (Student chosen topic)	3.600	1.046	20
	Exams	2.250	1.070	20
	Recitation	1.950	1.050	20
	Individual study	3.450	1.050	20

[4]This table shows the mean response and standard deviation, SD, the the questions asked in the ECES. The values displayed were found using data from all participants who responded to each question, to total number of responses, N, to each question are shown in the last column. Questions that contain multiple parts for responses list the subcategories next to the question number.

Table 8: 2017 Electrical and Computer Engineering Survey[5]

	QUESTION	MEAN	SD	N
9	Lecture	2.950	1.234	20
	Assigned reading	1.737	0.933	19
	Homework (weekly)	3.400	0.995	20
	Homework (daily)	2.200	1.056	20
	Labs	3.600	0.598	20
	Projects (assigned topic)	3.450	0.945	20
	Projects (Student chosen topic)	3.600	1.046	20
	Exams	2.250	1.070	20
	Recitation	1.950	1.050	20
	Individual study	3.450	1.050	20
10	ECE 486	3.059	1.298	17
	ECE 403	2.800	1.135	10
	ECE 343	3.000	0.926	8
	ECE 414	3.143	0.690	7
	ECE 401/5	3.000	0.966	16
	ECE 477	3.500	1.080	10
	ECE 331	4.800	0.632	10
	COS 431	5.000	NA	1
	ECE 478	4.250	0.957	4
	ECE 444	NA	NA	0

14 Appendix IV: IRB Approval Form

APPLICATION FOR APPROVAL OF RESEARCH WITH HUMAN SUBJECTS
Protection of Human Subjects Review Board, 418 Corbett Hall, 581-1498

(Type inside gray areas)
PRINCIPAL INVESTIGATOR: Thomas Leighton
EMAIL: thomas.leighotn@maine.edu TELEPHONE: (207) 478-6341
CO-INVESTIGATOR(S):
FACULTY SPONSOR (Required if PI is a student): Mauricio Pereira da Cunha
TITLE OF PROJECT: Investigation of the Relationship Between Freedom Allowed within Courses and Student Motivation.

START DATE: 1/23/17 ~~1/17/17~~ PI DEPARTMENT: Electrical Engineering
MAILING ADDRESS: 375 College ave. Orono, ME 04473
FUNDING AGENCY (if any):
STATUS OF PI: Undergraduate
FACULTY/STAFF/GRADUATE/UNDERGRADUATE

1. If PI is a student, is this research to be performed:

X	for an honors thesis/senior thesis/capstone?	☐	for a master's thesis?
☐	for a doctoral dissertation?	☐	for a course project?
☐	other (specify)		

2. Does this application modify a previously approved project? N (Y/N). If yes, please give assigned number (if known) of previously approved project:

3. Is an expedited review requested? N (Y/N).

Submitting the application indicates the principal investigator's agreement to abide by the responsibilities outlined in Section I.E. of the Policies and Procedures for the Protection of Human Subjects.

Faculty Sponsors are responsible for oversight of research conducted by their students. The Faculty Sponsor ensures that he/she has read the application and that the conduct of such research will be in accordance with the University of Maine's Policies and Procedures for the Protection of Human Subjects of Research

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FOR IRB USE ONLY Application # 2016-12-11 Date received 12/12/2016 Review (F/E): E
Expedited Category:

ACTION TAKEN:

X Judged Exempt; category 1&2 Modifications required? Y Accepted (date) 1/23/2017
☐ Approved as submitted. Date of next review: by Degree of Risk:
☐ Approved pending modifications. Date of next review: by Degree of Risk:
Modifications accepted (date):
☐ Not approved (see attached statement)
☐ Judged not research with human subjects

FINAL APPROVAL TO BEGIN 1/23/2017
Date

04/2016

15 Author's Biography

Thomas J. Leighton was born in Bangor, Maine on September 2, 1994. He was raised in Brewer, Maine and graduated from Brewer High School in 2013. Thomas is a senior Electrical Engineer at the University of Maine. He is interested in the field of robotics and sensors. Upon graduating, Thomas plans to attend graduate school at the University of Maine for Electrical Engineering and complete his minor in robotics.