Perspective of Teenagers on Traits and Research Associated with Electrical and Computer Engineers and their Research

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***Abstract*—Gender and diversity balance issues are prominent in the field of engineering. The way engineers and their research are perceived are two areas that contribute to youth deciding on careers in science and engineering. The perceptions of the youth on traits of Electrical and Computer Engineers (ECEs) and their research were explored through a survey of summer youth program students at Michigan Tech. Five different week long engineering programs were offered with surveys presented at the start and end of the contact times to observe how the activities and outreach impact the student perceptions. The perspectives of the youth show a lack of gender related trait association. After all different levels of contact, research area association with ECE was expanded. The largest areas displaying increased association were socially impacted areas, such as medicine. Increasing the association with these areas may help increase the interest of women in becoming engineers using the demographics of females in sciences as a statistical guide. This has shown that the benefit of engineering programs on perceptions and association is indifferent to curriculum and contact duration; that every bit of outreach makes a difference for the youth and prospects for improving gender balance in engineering.**

I. Introduction

Electrical and Computer Engineering (ECE) is one of the areas classified with science, technology, engineering and mathematics(STEM). Traditionally it is one of the disciplines with difficulty in achieving gender balance. The field of ECE is also a very diverse field. It plays an enabling role in almost every other area of science but its influence is often overlooked and many research areas are not considered to be associated directly with ECE.

In 2010, the NSF conducted a research study to determine the population of females (among other demographics) in engineering and other fields. Across all levels of education (bachelors-post doc), there were 1,569,000 individuals employed in engineering occupations, of which only 200,000 were female (12.75%). In Electrical Engineering there were 46,000 out of 385,000 (11.94%) [1]. Overall less then 20% of the engineering population is female [2].

To combat the gender disparity, many universities have week long summer programs in which young women participate in different types of engineering immersions. There are also co-educational programs which aim not only to promote women to become engineers but young men as well. These outreach programs target the recruitment and retention of engineers that is important to meet future needs [3].

Michigan Technological University(Michigan Tech) has programs every summer to promote STEM disciplines to youth. The students who participated in programs sponsored by the department of ECE during the summer of 2014 completed surveys at the start and end of the program to gain insight to the youth's perspectives on the traits of ECEs, what areas of research ECEs work with and the student's interest levels in engineering and ECE. The program sessions ran with either 6 contact hours or 31.25 contact hours depending on the program. At the end of the summer analysis of the collected data revealed that the students had an overall increase research areas associated with ECE after participating in both the 6-hour program and the 31.25 hour program.

II. Related Works

Often the research done looks at the vocational aspects of the engineer. Looking at if students viewed as working with trains, designing bridges, or even experiments; area were characterized at the higher level of research areas [4]. This approach is implemented as a test known as "Draw an Engineer Test".

Word association has been utilized before focusing on the impact of female authority views. There were 24 words utilized; 12 negative and 12 positive in meaning. The words used are shown in Table I and were considered as a base line in determining adjective traits for the survey.

Beyond drawing and word association, short answer responses have been used to acquire insight to the views of students. The use of these more expansive responses has been used in the analysis of retention, a factor in the production of engineers [3].

TABLE I
ADJECTIVES UTILIZED ON ADULTS FOR ASSOCIATION STUDY [5].

Positive Adjectives	Negative Adjectives
Clever	Bitter
Good	Annoying
Competent	Careless
Healthy	Cowardly
Intelligent	Cynical
Loyal	Dishonest
Likable	Forgetful
Optimistic	Gloomy
Pleasant	Harmful
Smart	Selfish
Honest	Snobish
Responsible	Bossy

III. METHODS

A. Setting

Annually Michigan Technological University hosts several thousand high school and middle school students over the course of a six week period. Some students stay for one week and some for multiple weeks of different programs. There are several program types, including two scholarship programs and week long residential and commuter immersion programs.

The department of Electrical and Computer Engineering (ECE) has five weeks of youth programs. There are four different curricula implemented through the different weeks. This study was conducted with the different groups of students in the ECE Summer Youth Program (SYP) sessions which can include up to 7 groups, 4 groups are from a scholarship program which had only 6 hours of contact time, 3 groups had 31 hours of contact time, 6 of the groups are high school aged and 1 group is middle school aged. The survey received exempt status from the internal review board at Michigan Tech on June 20, 2014.

The first session of the week started out with the survey. The same survey was administered at the end of the week to see what perceptions changed. Statistics on the population of each group were available (age distribution, gender distribution) through student rosters, and were not collected in the survey to maintain anonymity of the students. No observations were made by the instructor during the course of the programs.

The instructor and assistant were both females. The assistant was also an international student. The instructor held a MS in electrical engineering; the assistant a BS in electrical engineering. By presenting women in the authority role it effects the perceived stereotypes and, for the women in the room, can increase a sense of belonging related to the discipline. This environment offered the experience to present exposure to a statistically smaller aspect of ECE [6], which impacts the views of females belonging in engineering [3] and on female authority [7].

B. Collected Data

The general data of the number of students, their ages, and the gender distributions is collected from the Summer Youth Program (SYP) rosters. No personal information is collected. The survey to collect the information from the students is completely anonymous; has no information which can be connected back to the students. The surveys are combined to represent information for the collective groups in each program rather than individual students.

The survey consisted of 4 questions. The questions were either word selection or 5-point Likert Scale. The first question asked the student to circle adjectives which they associate with traits of electrical or computer engineers (ECEs). Table II shows the list of the adjectives that were presented as options for the students to select from as traits they associate with electrical and computer engineers. The second question focused on the areas of research that electrical and computer engineers are involved in. The research area options presented to the students are shown in Table III. This exploration of tracking the change in association of traits is consistent with the recommended practices for encouraging girls to pursue STEM presented in [6]. The third question asked the students to rate on a scale of 1-5 how interested they are in becoming engineers (with 5 being the very). The final question also asked for a scale opinion, but this time for their interest in becoming an electrical or computer engineer.

The responses to the first two questions were transposed to binary representation for each of the traits and research areas, the third and forth question were left in their numeric scaled form.

TABLE II
TRAITS STUDENTS WERE ABLE TO SELECT FROM IN THE SURVEY.

Smart	Loner
Preppy	Artistic
Geeky	Adventurous
Careful	Organized
Cautious	Energetic
Nerd	Athletic
Social	Masculine
Gamer	Feminine
Boring	Creative
Stubborn	Obsessive
Calm	Aggressive
Messy	Compassionate
Agreeable	

TABLE III
RESEARCH AREAS STUDENTS WERE ABLE TO SELECT FROM.

Computers	Circuits
Medicine	Energy
Environment	Biological
Robots	Sports
Automotive	Structural
Military	Theatrical
Aerospace	Art
Information Technology	Law
Business	Visualization
Software	Materials

IV. EXPERIMENTAL APPROACH

The survey instrument is distributed to the students to fill out while attendance is taken at the start of each week-long program session. At that point the students have only

minimal awareness of what they will learn and experience. In this manner the baseline opinion of the traits associated with electrical and computer engineers and the research that they do is established.

At the end of the program week, after the students return from lunch (or the start of the last group project session) the same survey instrument was distributed for the students to fill out. At this time the broader survey for Michigan Tech's Summer Youth Program is also administered. This timing was chosen so the instrument could be completed before the wrap up presentation that provides information on the career outlook and other components of electrical and computer engineering.

V. Curriculum Interactions

There were four different curriculum programs conducted during the summer. Each curriculum had different contact hours, different project objectives and different materials covered.

A. Women in Engineering Scholarship Program

The first week of youth programs every year is focused on encouraging young women to experience and consider STEM as a path for their futures. This program is known as Women in Engineering (WIE). These women ranged in age from 14 to 17 years old. The program has two academic components; engineering sessions and group projects. Engineering sessions are one hour long during which the student is introduced to key areas of engineering: mechanical engineering, civil and environmental engineering, chemical engineering and electrical and computer engineering. During the one-hour electrical and computer engineering session, students are introduced to different areas of research, career outlook, educational experiences to expect. They make a simple motor that they get to keep and then the remaining time is spent with hands on demonstrations ranging from a Van DeGraph generator to electromagnetism and various circuit examples like a "clapper" that turns a light on and off.

1) Curriculum: The WIE group project focused on connecting different aspects of electrical and computer engineering to provide a foundation to construct a programmable hand held persistence of vision (POV) device. Activities included making a picture book that when flipped through at different speeds students can see how speed effects what they see. Basic circuit theory was introduced with the construction of a simple potentiometer-resistor-LED circuit and simple RC high and low pass filter circuits. The students learn how to work DC power supplies, function generators and oscilloscopes. The basics of soldering was introduced with practice done on a free form approach. The students made bracelets and necklaces from used components soldered together. Once some confidence was built with the free form approach, perforated circuit board with copper pads was given to practice on. The students each constructed their own POV from a provided schematic and printed circuit board (PCB). The students then finished by programming the POVs to display messages of their choice using an open source website [8].

B. Engineering Scholarship Program

This program is aimed to provide the opportunity for students to attend a week long camp and experience STEM. This is a group of co-ed students ranging in age from 14 to 17 years old. This program is known as the Engineering Scholars Program (ESP) and it parallels the programmatic construction of the WIE scholarship program. The ESP program also has two academic components; engineering sessions and group projects. Engineering sessions are one hour long, during which the student is introduced to key areas of engineering: mechanical engineering, civil and environmental engineering, chemical engineering and electrical and computer engineering. During the one-hour electrical and computer engineering session, students are introduced to different areas of research, career outlook, educational experiences to expect. They make a simple motor that they get to keep and then the remaining time is spent with hands on demonstrations ranging from a Van DeGraph generator to electromagnetism and various circuit examples like a "clapper" that turns a light on and off.

The curriculum for this program was the same as the WIE week.

C. Electrical and Computer Engineering Immersion

During the third week of the summer program a co-ed group of high school students, ages 15-17, came to learn about electrical and computer engineering. The contact time for this curriculum is 3 hours in the morning and then 3.25 hours in the afternoon, totalling 31.25 hours of contact over the week.

1) Curriculum: Topics from multiple areas of ECE were explored. Circuit theory is introduced with activities including circuits with LEDs, integrated circuits, switches and potentiometers. The students worked in pairs to design their own printed circuit boards (PCBs) that were fabricated. The students soldered the circuit components to the boards later in the week. Students explored basic computer architecture through gaming. Each student played a role such as a piece of data, the bus, or CPU. There were secret messages coded in ASCII and a chance to design their own video games using MIT's Scratch.

D. Mobile Robotics

This week is an exploration of robotic basics using Lego Mindstorms and a PCB robot with a Texas Instruments (TI) MSP 430 microcontroller. The curriculum during this week provides 3 three hours of contact time in the morning and then 3.25 hours in the afternoon, totalling 31.25 hours of contact over the week.

1) Curriculum: The students explored ways to program and design Lego Mindstorms robots to accomplish goals of various levels of difficulty. The TI MSP 430 was used as a basic microcontroller which they programmed in C to follow a line marked on the floor using IAR.

E. Beginning Mobile Robotics

The curriculum for the Beginning Mobile Robotics week brings middle school students of ages 10 to 14 years old to

explore basics of robotics. The contact time for this curriculum is 3 hours in the morning and then 3.25 hours in the afternoon, totalling 31.25 hours of contact over the week.

1) Curriculum: The students worked through nearly a dozen programing challenges utilizing Lego Mindstorms which they constructed and programmed using a graphical user interface. The students learned basic circuit theory and soldering skills to construct their own escape bot from a provided PCB kit.

VI. Results

Over the course of 5 weeks, 99 different students participated in SYP programs hosted by the ECE department, with 51 students in the week long (31.25 contact hour) immersion courses and 48 in the (6 contact hour) scholarship programs. The age distributions are shown in Table IV with the gender distributions shown in Table V.

TABLE IV
AGE DISTRIBUTIONS

Week	Age							
	10	11	12	13	14	15	16	17
WIE AM	0	0	0	0	0	2	4	5
WIE PM	0	0	0	0	0	2	5	5
ESP AM	0	0	0	0	2	2	2	7
ESP PM	0	0	0	0	0	4	5	4
ECE	0	0	0	0	0	6	7	7
Mobile Robotics	0	0	1	0	2	6	5	1
Beg. Mobile Robotics	1	1	5	7	2	0	0	0

A. Trait Association

The types of adjectives students could select from were positive, negative, behavioral and then adjectives which can be both positive and negative (combined)[5]. The differences in adjectives can be seen in the referenced words in Table I and in Table VI which were used in the study.

The association of descriptive traits with electrical and computer engineers is a factor in the image of the discipline and how the individuals in the field are perceived. The survey results from the start of the week show that the top three traits students associated with ECEs are smart (95.96%), creative (77.78%), and organized (63.64%). The least associated traits were athletic (3.03%), boring (3.03%) and preppy (3.03%). The student's responses can be seen in Figure 1.

At the end of the week, the student's associations of smart, organized and creative were still the most associated traits. The least associated traits at the end of the week were feminine, masculine, and athletic all with 8 out of 99 students (8.08%). The biggest change in trait association were agreeable (23.23%) and calm (24.24%). All traits saw an increase in associations except for gamer, which saw a 5% decrease.

TABLE V
GENDER DISTRIBUTIONS

Program	Female	Male
WIE AM	11	0
WIE PM	12	0
ESP AM	0	12
ESP PM	1	12
ECE	1	19
Mobile Robotics	2	13
Beginner Mobile Robotics	3	13

TABLE VI
ADJECTIVE CONNOTATIONS.

Positive	**Negative**	**Behavioral**	**Combined**
Smart	Loner	Artistic	Nerd
Careful	Boring	Preppy	Masculine
Organized	Stubborn	Adventurous	Feminine
Compassionate	Messy	Gamer	Cautious
Calm	Aggressive	Artistic	Geeky
Social	Obsessive	Creative	
Energetic		Athletic	

There were 2 more students who associated ECEs as masculine and 4 more that associated female at the end of the week compared to the beginning of the week. The increase in gender association is not surprising since there is a traditional gender gap in STEM. Initially, there was more association with masculine than feminine, which resembles the distribution of women in ECE. The result at the end of the week was a balanced association of the genders. It can be interpreted that in the absence of a gendered trait association, the students view things as non gendered, which at the end of the program is 92% of the time.

B. Research Areas

The number of research areas that students associated with ECE increased from the start of the week to the end of the week. Figure 2 shows the thinner(red) lines as the ending percent of students who associate with the research area with ECE, with the thicker (blue) lines being the initial responses.

The research areas that were associated with ECE all increased after the week of experience. The areas of largest increase include medicine, environmental, biological and art. These areas are associated with ECE through the expansion of inter-disciplinary and collaborative work. The one surprise is that there was not an 100% association of the research areas computers and circuits.

The impact of the week is actually best measured in the expansion of what research ECEs do. On average, the number of areas which are associated with ECE increases by 100 areas (34.2%), which the smallest expansion of areas seen in the WIE am section with a net increase of 10 areas (4.5%), and the largest expansion seen in the ESP am group with an average increase of 73 areas (37.8%).

Established association for women to prefer careers that benefit the social good [9], makes the observed expansions of association a desirable outcome. The increase in the association for the socially beneficial research areas such as medicine (40% increase), environmental (33% increase), and biological (33% increase) are supportive of associating ECE with female preferred fields. This association increase should have a positive impact on the women joining ECE.

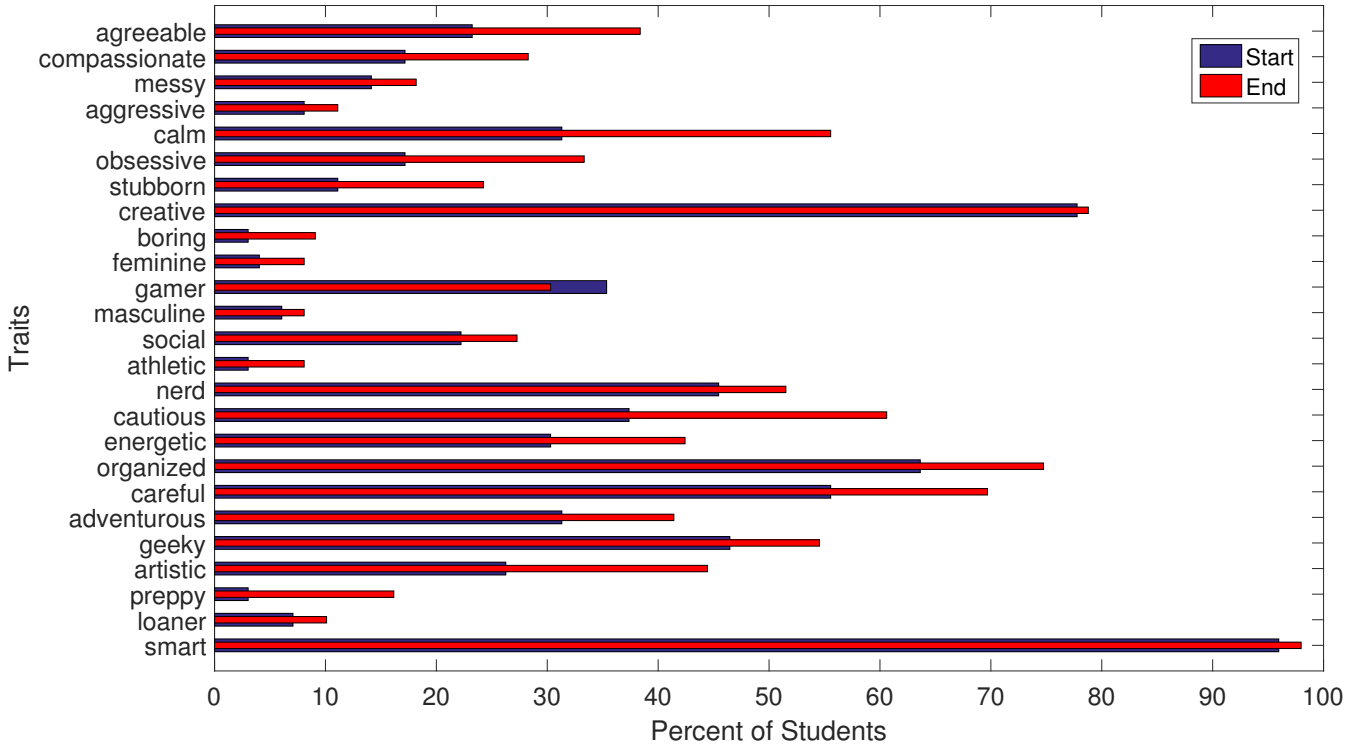

Fig. 1. The percent of students from all weeks that associate the trait with ECEs.

With the demographics (Table V) seen in a majority of the weeks, this area association increase is not something that will likely impact the gender imbalance currently prevalent, but it supports a more multi-disciplinary mind set for the students.

TABLE VII
NET COUNTS OF THE RESEARCH AREAS STUDENTS ASSOCIATED WITH ECE.

Program	Net Start	Net End	Net Change	% Change
WIE AM	116	126	10	7.9
WIE PM	121	163	42	25.7
ESP AM	120	193	73	37.8
ESP PM	137	193	56	29
ECE	220	320	100	34.2
Mobile Robotics	125	190	65	34.2
Beginner Mobile Robotics	134	182	48	26.4

TABLE VIII
NET PERCENT OF THE RESEARCH AREAS STUDENTS ASSOCIATED WITH ECE.

Program	Net Start	Net End	Change
WIE AM	52.7	57.2	4.5
WIE PM	50.4	67.9	17.5
ESP AM	50	80.4	30.4
ESP PM	52.7	74.2	21.5
ECE	55	80	25
Mobile Robotics	41.6	63.3	21.7
Beginner Mobile Robotics	41.8	58.9	17.1

C. *Interests*

The idea of measuring the interests of youth to see the if hands-on activities and exposure to different aspects of electrical and computer engineering and STEM is something that a simple numerical scale may not be able to quantify. Each student is multidimensional with various interests and things that they enjoy and excel at, so to try to improve their interest in electrical and computer engineering or engineering in general is dependent on too many factors.

TABLE IX
INTEREST CHANGES

Program	**Net Change in Interest in Engineering**	**Net Change in Interest in ECE**	**% Net Change Engineering**	**% Net Change in ECE**
WIE AM Group	-3	2	-5.4	3.6
WIE PM Group	4	2	7.2	3.6
ESP AM Group	3	0	5	0
ESP PM Group	-1	3	-1.5	4.6
ECE	-2	-6.5	-2	-6.5
Mobile Robotics	6	5	8	6.6
Beginning Mobile Robotics	4.5	-0.5	5.6	-0.6

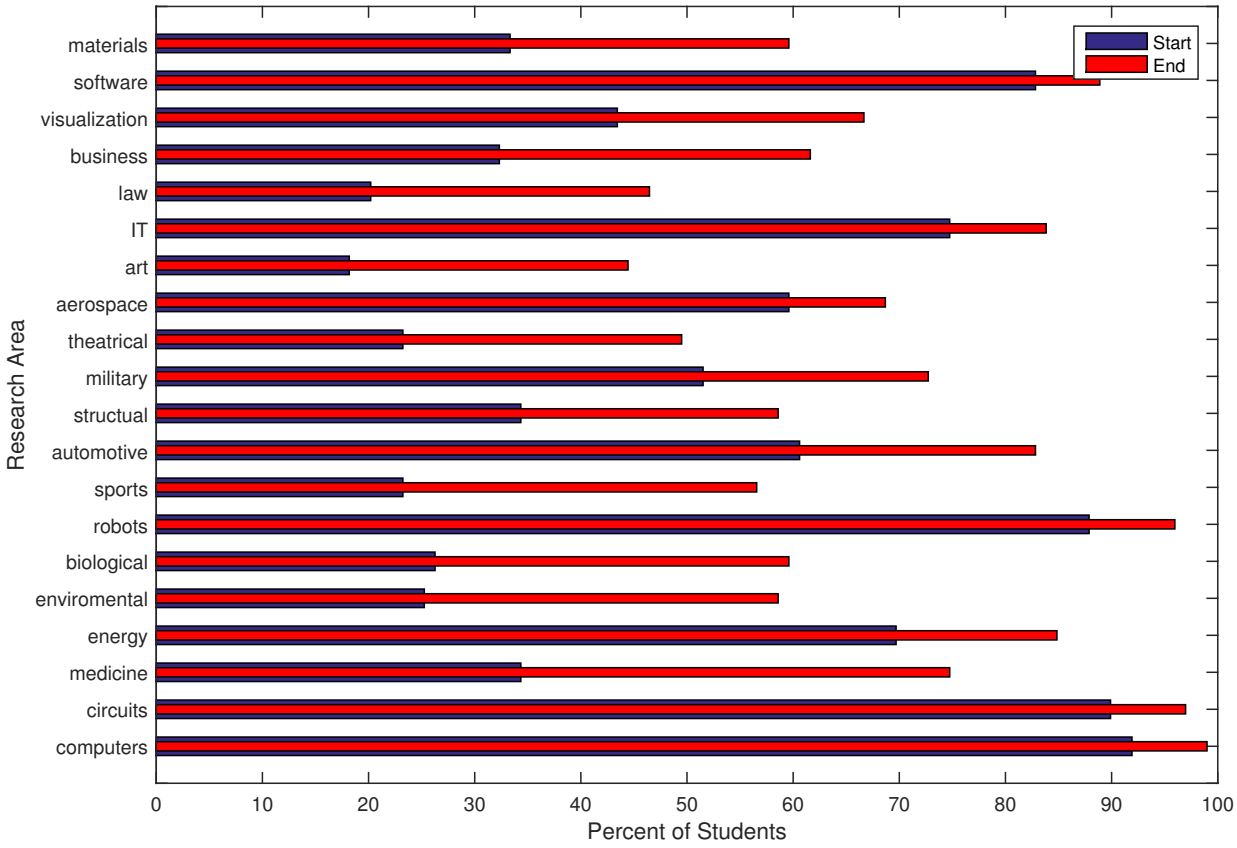

Fig. 2. The number of students from all weeks that associate the research area with ECE. Dark blue thinker line is start, red thinner line is at the end of the week.

The net experiences for each week can be seen as the summation of the scores the students gave for their interests in the start of the week and the end of the week, seen in Table IX.

The only week to experience a complete negative change in interest is the ECE week, which shows the most different areas of the discipline. Seeing a net change of 3.6% increase with the WIE students for ECE is a positive result, and in the afternoon section seeing 7.2% increase for engineering is very positive. When the percentage of women in the discipline is only about 12%, a growth in interest of 7.2% is significant.

TABLE X
NORMALIZED INTEREST AT THE END OF THE WEEK.

Program	**Net % Interest in ECE**	**Net % Interest in Engineering**
WIE AM Group	67	82
WIE PM Group	72	96
ESP AM Group	83	96
ESP PM Group	76	89
ECE	81.5	91
Mobile Robotics	67	80
Beginning Mobile Robotics	76.8	86

Normalizing percentages for interest, Table X is produced. This is suggestive that 88.5% of the students this past summer will become engineers (based on the average of the net normalized interest). This takes their interest level as a direct relation to the likelihood that they will become engineers. The percentage for ECE is 74.8%. Overall the interest in engineering ended strong, one of the desired outcomes for STEM outreach programs.

VII. FUTURE WORK

To continue the exploration further we have planned for a new male instructor to repeat the survey in a future summer with a very similar set of curricula and students demographics. This we expect to show how things have changed over time since the initial survey were done and the impact of the gender of the instructor. An extension of the survey to consider is to do the survey with a different demographic such as the first year university engineering fundamentals programing with the surveys done at the start, middle, and end of the year long program.

VIII. Conclusion

The broader objective for this investigation is the hypothesis that the experiences of the students through outreach programs will more electrical or computer engineers in the future. Promoting engineering to the youth, and the retention of engineers are also important components. From the time that students enter college until they graduate, 40% leave STEM [3]. While studies have been done to see why students leave, the change of perspectives, associations and interests may provide further insight.

The growth of association of research areas is beneficial to the development of future engineers. The increased association of electrical and computer engineering with socially impacting research areas that draw women to the field [9] may prove to be helpful in reducing the female imbalance in the career field. The influence on redefining the boundaries of research is one of the more positive aspects of the influence that the Electrical and Computer Engineering Departments programs had on the students.

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