IMPACT OF PARENT MENTORING AND PARTICIPATION IN FIRST ROBOTICS ON MIDDLE AND HIGH SCHOOL AGE FEMALE PERCEPTIONS OF ENGINEERING CAREERS

An Abstract of a Thesis

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

Kirsten Olson

University of Northern Iowa

December 2019

ABSTRACT

Female presence within engineering careers has been a growing concern for decades, as females continue to major in engineering at a far lesser rate than males. Females may be affected by many different environmental factors, from parental influence, early engineering experiences, negative stereotypes present in male dominated careers, and male dominant culture in content classes and the workplace. Researchers have explored ways in which the gender gap within engineering can be closed, such as heightening females' self-efficacy and providing early STEM experiences. Early engineering experiences include the FIRST (For Inspiration and Recognition of Science and Technology) Programs, where students are submersed in an engineering experience that includes building a team robot.

The engineering program FIRST allows parent mentors to serve on teams, to provide guidance and advice as students engage in the engineering process. This study focused on relationships between parent mentoring on FIRST robotics teams and female interest in pursuing engineering and computer science related careers, along with the effect of FIRST experiences on female perceptions of engineering. From the study, female student confidence to become an engineer or a computer scientist was high after being involved in FIRST, but interest was low. This presents a confidence/interest gap that may need to be explored further. The effect of parent mentors on female student perceptions of engineering was explored, although the population of students surveyed was very low, which didn't give enough data to draw accurate conclusions. From the student interview, mentors effect on perceptions of engineering was discussed. From opinions expressed by the student, mentors may help with confidence/interest in engineering and computer science, and may also help students stay interested and motivated to pursue the career.

IMPACT OF PARENT MENTORING AND PARTICIPATION IN FIRST ROBOTICS ON MIDDLE AND HIGH SCHOOL AGE FEMALE PERCEPTIONS OF ENGINEERING CAREERS

A Thesis

Submitted

in Partial Fulfillment

of the Requirements for the Degree

Master of Arts

Kirsten Olson

University of Northern Iowa

December 2019

This Study by: Kirsten Olson

Entitled: Impact of Parent Mentoring and Participation in FIRST Robotics on Middle and High School Age Female Perceptions of Engineering Careers

has been approved as meeting the thesis requirement for the

Degree of Master of Arts

Date	Dr. Jeffrey Morgan, Chair, Thesis Committee
Date	Dr. Dawn Del Carlo, Thesis Committee Member
Date	Dr. Jill Maroo, Thesis Committee Member
Date	Dr. Sarah Diesburg, Thesis Committee Member
Date	Dr. Jennifer Waldron, Dean, Graduate College

ACKNOWLEDGEMENTS

Special thanks to Dawn Del Carlo, Jeffrey Morgan, and my thesis committee for all of their hard work and help with this Master's Thesis. Also, special thanks to my family and friends for supporting me and helping me achieve this next step in my education.

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

FIGURE PAGE

CHAPTER 1

INTRODUCTION

Gender disparity within the Science, Technology, Engineering, and Mathematics (STEM) fields has been a concern for decades, although gender diversity within some STEM fields is more prominent than others. “Women obtain more than half of U.S. undergraduate degrees in biology, chemistry, and mathematics, yet they earn less than 20% of computer science, engineering, and physics undergraduate degrees” (Cheryan, Ziegler, Montoya, & Jiang, 2017, p.1). For decades, women in college continue to enroll in STEM majors less often than men, but particularly in the field of engineering (Jacobs, 1995, 1996; Sax, 2008; Kanny, Sax, & Riggers-Piehl, 2014; Brush, 1991).The question remains; Why are women pursuing some STEM fields, but not others? Despite encouragement, dramatic drops in women pursuing engineering as a career have occurred (Kanny et al., 2014). Therefore, the field of engineering is missing out on female contributions, which would bring even more creative ideas and intelligence to the field (Cheryan et al., 2017). A society unable to correct this gender imbalance cheats itself of important and meaningful contributions from significant citizens (Zeldin & Pajares, 2000).

Personal beliefs about ability may be hindering women from pursuing a career in engineering (Zeldin & Pajares, 2000; Cheryan et al., 2017). Self-efficacy research concluded that women’s personal beliefs often originate from significant people in their lives (Zeldin & Pajares, 2000). Thus, in order for young women to pursue non-traditional majors, such as engineering, they are more likely to successfully complete their degree with some sort of mentoring (Quimby & Santis, 2006). Previous studies concerning family involvement explored ways in which women were influenced by family members. Sonnert (2009) found that women scientists were more likely to be influenced by a father role model rather than a mother role model, especially if that father figure was working in a STEM related career. Although previous research discovered that male mentors may have more of an impact on young females pursuing non-traditional careers, it is unclear whether or not that is because of the large population of males within STEM fields.

Young girls show more interest in pursuing engineering fields when they are provided with an early experience with engineering (Cheryan et al., 2017). Programs that provide this type of experience include For Inspiration and Recognition of Science and Technology (FIRST) Robotics (FIRST, 2018). Robotics programs not only provide early engineering experience, but offer encouragement and heighten self-efficacy (Welch & Huffman, 2011). FIRST Robotics programs, open to both male and female students, provide themed missions and technical scenarios that allow students to engage in engineering practices and use critical thinking strategies to solve problems (Fletcher & Haag, 2016). Through these problem-based engineering experiences, students involved in FIRST Robotics prove to be more successful in engineering programs (Fletcher & Haag, 2016). Therefore, FIRST can be used to prepare students for admission, success and completion in engineering programs (Fletcher & Haag, 2016).

Recent gender diversity research regarding STEM shows a large gap in literature regarding female participation in engineering majors and its connection to family involvement (Kanny et al., 2014). This research focused on ways to encourage young women and girls to pursue STEM careers such as engineering. Although efforts are made, a drop has occurred in female involvement in engineering fields (Kanny et al., 2014). Other gaps in research exist in the effect of FIRST programs on students pursuing STEM related careers.

The purpose of this study is to explore the impact of parent-mentoring through participation in FIRST Robotics on middle and high school age female perceptions of engineering careers. This study will build on previous research concerning the underrepresentation of women within the field of engineering.

CHAPTER 2

LITERATURE REVIEW

Women in STEM

Women earn approximately 37% of all undergraduate STEM degrees (Cheryan et al., 2017). In some areas of STEM, such as biology, the majority of graduates are women. The National Science Foundation surveyed students beginning their freshman year at undergraduate institutions in the United States (Falkenheim, Burke, Muhlberger, & Hale, 2017).

The National Science Foundation (2017) surveyed students beginning their freshman year at undergraduate institutions in the United States. Out of all undergraduate freshman surveyed, 37.5% of females intended to major in a STEM field (Table 1). 15.8% intended to major in biology or agriculture science, making up approximately half of all women majoring in STEM. Of males, 11.4% intended to major in these fields (Table 1). For biology and agriculture science, females complete these majors far more often. Within the careers associated with these types of degrees, there are a larger percentage of women working. When comparing these statistics to some of the other STEM fields, there is a much larger gender gap. For example, when comparing the percentage of women intending to major in engineering to the percentage of men, women intend to major in engineering at a far less rate than men. Only 5.8% of women intend to major in engineering, whereas 19.1% of males responded that that was their plan (Table 1). The gender gap is also noticeable in areas of physical science, math, statistics and computer science, although the gender gap within these fields are much smaller. For example, women intend to major in physical science at a rate of 2.1%, whereas males are reporting a higher 3.2% (Table 1). Although males tend to major in physical sciences at a higher rate than females, the gender gap in this area of STEM is much smaller, but still a concern. The question stands, why is the gender gap less prevalent in some areas of STEM, but still so apparent in engineering? What factors may be contributing to the underrepresentation of women within engineering?

Table 1

Intentions of Freshman to Major in Science and Engineering Fields in 2017[a]

Gender	All STEM Fields	Biology and Agricultur e Science	Engineeri ng	Math, Stats & Computer Science	Physical Science[b]	Social & Behavior Science
Female	37.5%	15.8%	5.8%	2.1%	2.1%	11.7%
Male	49.0%	11.4%	19.1%	7.8%	3.2%	7.5%

Note. Adapted from Falkenheim et al. (2017).

[a]Includes first-year students at surveyed 4-year colleges.
[b]Physical sciences include physics, chemistry, astronomy, and earth, atmospheric, and ocean sciences.

Previous research identifies a variety of factors that relate to women's underrepresentation within STEM, including: (1) masculine cultures, (2) lack of sufficient early experiences, (3) gender gaps in self-efficacy, (4) imposter syndrome, and (5) stereotype threat (Cheryan et al., 2017; Lindemann, Britton, & Zundl, 2016). STEM fields in these studies include chemistry, computer science, information technology, engineering, geosciences, life sciences, mathematical sciences, and physics.

The first factor contributing to the underrepresentation of women is the idea of masculine cultures. With engineering careers being dominated by males, the culture within that field may hinder a sense of belonging for many females. A misconception about engineering is that it is a field in which heavy work is done with construction and machinery, therefore, it is viewed by some as much more “masculine” than other science fields (Brush, 1991). Because of the masculine culture, values, and structures within engineering, it is difficult for many women to see themselves fitting into that career (Cheryan et al., 2017). Although it is unclear how this change may be accomplished, changing the cultures to be more female-welcoming may encourage more women to pursue engineering.

Another negative piece that comes with male-dominance within engineering careers are the stereotypes that follow. Engineering is stereotypically associated with males, meaning that an engineer in general is believed to have more masculine traits and interests (Cheryan et al., 2017). Since this stereotype is prevalent within engineering, this may deter females from becoming engineers.

Besides stereotypes associated with engineering, women may also believe that they are inferior to men based on preconceived ideas about women’s intelligence. Early research regarding sex differences “implied that women are inferior to men in the cognitive abilities needed for success in science: spatial visualization and mathematical skills” (Brush, 1991, p. 406). With early research implying that females are inferior to males, women may feel less welcomed in a male-dominant field highly associated with male stereotypes. Although some of these stereotypes still exist, more recent research shows that there is not a difference in ability. In a study conducted by Tarampi, Heydari, and Hegarty (2016), women's spatial abilities were tested, which are stereotypically thought to be inferior to that of men. To test spatial abilities, two separate tests were given to college aged students, which asked them to think about locations of objects from different perspectives than their own. The first test tested spatial ability, but also explicitly stated in the instructions that men commonly outperform women on this type of test. The results indicated that men outperformed women. On the other, they tested spatial ability with similar questions, but explicitly stated in the instructions that women tended to do better than men on the test. The results of the second exam showed that the gender gap in spatial reasoning disappeared. Even more intriguing, men's performance, no matter the test given, remained the same. Although many of these misconceptions in ability have been disproven, recent research concluded that some of these gender misconceptions may still exist. Hill, Corbett, and St. Rose stated:

> "not only are people more likely to associate math and science with men than with women, people often hold negative opinions of women in "masculine" positions, like scientists or engineers. Research profiled in this report shows that people judge women to be less competent than men in "male" jobs unless they are clearly successful in their work. When a woman is clearly competent in a "masculine" job, she is considered to be less likable. Because both likability and competence

> are needed for success in the workplace, women in STEM fields can find themselves in a double bind" (2010).

Because some of these negative misconceptions still exist today, many females may feel less welcomed in a male-dominant field.

Secondly, women may be underrepresented within the field of engineering due to a lack of early engineering experiences, which may be a result of the stereotypes associated with engineering careers (Cheryan et al., 2017). In fact, there may be fewer opportunities available to women because the burden of a male-dominated field creates no female interest to participate in early engineering experiences. For this reason, programs such as FIRST Robotics aim to provide early experiences with engineering type projects for both females and males. Other early experiences may be due to an outside influence or mentor.

Third, women may be less represented within engineering because of gender gaps in self-efficacy (Cheryan et al., 2017). Self-efficacy refers to one's belief in their ability to perform actions or tasks (Bandura, 1997). In a study conducted by Zeldin and Pajares (2000), self-efficacy beliefs were an important factor in helping women select a career in mathematics, science, or technology. Research on self-efficacy and its effect on women in STEM verified that experience and persuasion were huge variables in developing and maintaining self-efficacy (Zeldin & Pajares, 2000). Performance on tasks doesn't have an effect on self-efficacy. Therefore, doing well on something previously doesn't contribute to beliefs in oneself as much as vicarious experiences and verbal persuasion (Zeldin & Pajares, 2000). Vicarious experience is experience gained indirectly, such as through reading a book. Verbal persuasion is encouragement from outside sources, which makes one feel capable (Zeldin & Pajares, 2000).

Self-beliefs or self-efficacy stemming from influential interactions may help women pursuing male-dominant careers. Influential people within women's lives were found to have a large impact on their career choice (Zeldin & Pajares, 2000). "Women recalled critical episodes in which the interactions they had with a family member led to efficacy-building experiences" (Zeldin & Pajares, 2000, p. 227). For example, in a study conducted by Zeldin and Pajares (2000), one woman interviewed specifically accredited her relationship with her parents to her ability to overcome obstacles and heighten her self-efficacy. Encouragement from family and friends "may help individuals to exhibit the extra effort and maintain the persistence required to succeed, resulting in the continued development of skills and of personal efficacy" (Zeldin & Pajares, 2000, p. 217). Women that develop a strong sense of self-efficacy will persist longer, and be more successful in the face of adversity. Therefore, strong self-efficacy beliefs enable women, especially in a male-dominated domain such as engineering. In fact, without the self-efficacy-building relationships present, women may become discouraged in their aspirations to pursue a career in mathematics related fields, such as engineering (Zeldin & Pajares, 2000).

Fourth, when women do find success within a STEM career, they often fail to attribute their success to their own abilities. Failure to attribute their success to their abilities may cause some women to become disengaged in their career. This leads some women to view themselves as "imposters that will soon be discovered," otherwise known as imposter syndrome (Lindemann et al., 2016, p. 222). Research conducted by Lindemann et al. (2016) showed that imposter syndrome contributes to women's disengagement from a STEM major or field. At a "State University" explored in the study, many STEM prerequisites took on the form of a lecture-based class with large numbers of students. In every focus group, students communicated that class size was a deterrent to their STEM participation, as many times connections between peers weren't made. This lack of connection was directly related to "imposter syndrome." These students described feeling alienated, and feeling as though everyone in the class seemed to understand the material easily, while they were left feeling confused, unsure, and out of place (Lindemann et al., 2016).

An undergraduate institution-level factor contributing to imposter syndrome is known as weed out culture (Lindemann et al., 2016). Weed out culture is well-known by students in some STEM related courses throughout many institutions. This culture, communicated to students by large class sizes organized by the institution and instructor actions, hopes to keep students in STEM career paths who exhibit determination and perseverance. Although institutions hope to keep strong students in these classes, weed out culture can become disheartening and discouraging for many students, including females' who already are working to overcome gender disparity. Lindemann et al. (2016) found that students spoke of low exam averages and professors who actively encouraged students to drop their courses. "It is not difficult to imagine how weed out culture might deepen feelings of inadequacy, for women and other underrepresented STEM students who are already at greater risk for imposter syndrome" (Lindemann et al., 2016, p. 231).

Parents and peers can play a huge role when it comes to female retention in these STEM related classes and feelings of "imposter syndrome" (Lindemann et al., 2016). At the institutional level, having relationships with peers and parents can serve as support systems for students struggling with weed out culture. Findings from the study conducted by Lindemann et al. (2016) showed that students studying at institutions displaying weed-out culture who had family members involved in STEM had an advantage when it came to persistence. Additional information from parents or peers about the institution or class was especially helpful to these students when it came to feelings of imposter syndrome and weed out culture.

Furthermore, programs and communities designed for young women and students pursuing STEM also may help female students from feeling like an imposter in their field (Lindemann et al., 2016). In these intervention programs, students are surrounded by peers who are also struggling with similar content and classes. Time spent in the programs or communities allows students to communicate their struggles with their peers. Being in this environment allows students to feel as though they are not alone, and gives them a support system within their institution. This support system not only helps students lessen feelings of imposter syndrome, but also has shown to help students through classes displaying weed out culture (Lindemann et al., 2016).

The last major factor contributing to female attrition within STEM is known as stereotype threat. Stereotype threat impacts women when they become aware of the negative stereotypes surrounding women's abilities and their success within STEM careers (Lindemann et al., 2016). The pressure to overcome these stereotypes and to avoid making them a reality for themselves negatively affects women's overall performance (Lindemann et al., 2016). Responses from students that participated in the study conducted by Lindemann et al. (2016) show that stereotype threat is a very prominent thing for many females in STEM career paths. Participating students mentioned two major factors contributing to stereotype threat: 1) parent/guardian support and 2) large lecture classes (Lindemann et al., 2016). First, some students expressed that they were discouraged from pursuing STEM careers by their parents/guardians simply because they were female. For example, a student participating in the study described that a parent/guardian expressed that they should study something that would take less time for them to complete, since they are a woman and they needed to have children (Lindemann et al., 2016). Secondly, females also expressed feelings of stereotype threat when being in a class lecture hall of hundreds of students where they were one of the few females in a class of several hundred males. Because of this imbalance, they felt singled-out, and many thought their peers and their professor expected they would need help with the course content, simply because they were female (Lindemann et al., 2016). One student expressed that she felt "afraid to raise your hand because you might be 'the dumb one'" (Lindemann et al., 2016, p. 234). This response shows just how detrimental large lectures and stereotype threat can be to female attrition in STEM.

Women in Engineering and Computer Science

In the past 60 years, engineering graduation rates in the United States have remained almost unchanged, at a consistent 50% (Geisinger & Raman, 2013). This engineering graduation rate implies that of all students that declare engineering as a major, half leave their programs prior to graduation. Only 21% of first-year engineering majors are female (Falkenheim et al., 2017). Of those women, “the national retention rate estimates for women, calculated as the ratio of students who complete an engineering program to the number of incoming freshmen four years earlier, are slightly below 60%” (Brainard & Carlin, 1998, p.369). This is better than average, meaning that of the few women that choose engineering, many are successful at sticking with it.

The most recent data published by the National Science Foundation for engineering degrees awarded in 2016 shows just how large the gender gap is (Falkenheim et al., 2017).Women receive degrees in engineering at a far lesser rate than men. Males receive approximately three-fourths of all Bachelor’s degrees, Master’s degrees, and Doctoral degrees in engineering (Table 2). The number of degrees awarded to men greatly outnumber the degrees awarded to females. Females receive approximately one-fifth of Bachelor’s degrees, one-fourth of Master’s degrees, and one-fourth of Doctoral degrees in engineering (Table 2). The biggest issue seems to lie in the amount of female students that enter engineering programs, and the numbers speak to exactly how large and detrimental the gender gap in engineering may be.

Table 2

Engineering Degrees Awarded in 2016

Degree Type	Total Degrees Awarded	Female Degrees	Female Degree Percentage	Male Degrees	Male Degree Percentage
Bachelor's	108,976	22,794	20.9%	86,182	79.1%
Master's	55,166	13,789	25.0%	41,377	75.0%
Doctoral	10,358	2,429	23.5%	7,929	76.5%

Note. Adapted from Falkenheim et al. (2017).

Additionally, the National Science Foundation published information regarding computer science degrees awarded to male and female students in 2016 (Falkenheim et al., 2017). In some studies, computer science is regarded as a facet of engineering. In this case, they were published as two different sets of data. Since the STEM program studied in this research study also includes computer science, it was necessary to discuss the gender gap in this data as well.

The large gender gap within engineering is analogous to the gender gap within computer science. Males receive a large proportion of Bachelor's degrees, Master's degrees, and Doctoral degrees in computer science (Table 3). The number of degrees awarded to men greatly outnumber the computer science degrees awarded to females. Females receive 62.6% less Bachelor's degrees, 38.4% less Master's degrees, and 59.8% less Doctoral degrees in computer science (Table 3). Comparatively, the gender gap within both engineering and computer science is disconcerting. More research into the variables affecting this large gender gap needs to be conducted.

Table 3

Computer Science Degrees Awarded in 2016

Degree Type	Total Degrees Awarded	Female Degrees	Female Degree Percentage	Male Degrees	Male Degree Percentage
Bachelor’s	65,186	12,222	18.7%	52,964	81.3%
Master’s	40,211	12,372	30.8%	27,839	69.2%
Doctoral	1,936	389	20.1%	1,547	79.9%

Note. Adapted from Falkenheim et al. (2017).

After degrees have been awarded, engineering and computer science graduates may or may not work in an engineering occupation. The National Science Foundation published statistics highlighting the percentage of men and women working in engineering careers in 2017 (Falkenheim et al., 2017). From this data, the number of men currently working in an engineering occupation greatly outnumbers the number of women. For all levels of engineering degrees, approximately 15.6% of all employed persons are female while 84.4% are male (Table 4). These statistics illustrate the huge discrepancy between male and female engineers employed within the workplace. When comparing the overall percentage of women employed in engineering occupations to level of degree obtained, the lowest percentage of females are employed in engineering occupations with Doctorate degrees (13.8%), whereas the highest percentage of females employed have Master’s degrees (19.0%) in engineering (Table 4). Comparatively, the percentage of males employed in engineering occupations with all degree types averages approximately 84%, and remains fairly consistent for all degree types (Table 4). Overall, this data identifies not only a gender gap between male and female engineers in the workplace, but a gap between those graduating with engineering degrees compared to those with degrees working in an engineering occupation. Of those obtaining engineering degrees, not all of these graduates utilize their degree in a career. More research needs to be conducted to explore the variables causing graduates to no longer continue in their field of study. A few possible variables may be that women are leaving the workforce to have families, or the negative environment that many females experience in their engineering education or workplace.

Comparatively, data collected by the National Science Foundation conveys a similar trend occurring with computer science degrees and those employed in computer science occupations (Falkenheim et al., 2017). This data illustrates the large gender gap within computer science occupations, as for all degree types, approximately 25.4% of employees are female whereas 74.5% are male (Table 5). For females, a Bachelor's degree in computer science tended to be less common in the workplace (24.6%), compared to the more common Master's degree (27.2%) (Table 5). This was no comparison to the number of males employed in a computer science occupation in 2017. For males, a Master's degree in computer science tended to be less common (72.8%), while the Bachelor's degree in computer science (75.4%) tended to be most common in the workplace (Table 5).

Table 4

Engineer Degree Recipients Employed in Engineering Occupations in 2017

		Females		Males	
Degree Type	Total Employed	Employed	Percentage Employed	Employed	Percentage Employed
All	1,728,000	269,000	15.6%	1,459,000	84.4%
Bachelor's	1,061,000	149,000	14.0%	912,000	86.0%
Master's	549,000	104,000	19.0%	445,000	81.0%
Doctorate	116,000	16,000	13.8%	100,000	86.2%

Note. Adapted from Falkenheim et al. (2017).

Table 5

Computer Science Degree Recipients Employed in Computer Science Occupations in 2017

		Females		Males	
Degree Type	Total Employed	Employed	Percentage Employed	Employed	Percentage Employed
All	3,096,000	787,000	25.4%	2,309,000	74.5%
Bachelor's	2,096,000	515,000	24.6%	1,581,000	75.4%
Master's	911,000	248,000	27.2%	663,000	72.8%
Doctorate	78,000	20,000	25.6%	58,000	74.4%

Note. Adapted from Falkenheim et al. (2017).

The data provided by Falkenheim et al. (2017) shows the dramatic difference in the number of males versus the number of females working in engineering and computer science based occupations in 2017. From the data, one can conclude just how important research concerning the gender gap may be, as engineering and computer science occupations are missing out on the creative ideas and intelligence that female contributions will bring (Cheryan et al., 2017). Besides missing contributions, an imbalance of gender can affect women currently employed in these occupations as well. An imbalanced gender ratio can activate negative stereotypes about women's abilities, and bring about underperformance to the women already working within those fields (Cheryan, Siy, Vichayapai, Drury, & Kim, 2011). Therefore, if one seeks to increase female representation and contributions within the engineering field, then more research would be required to explore the factors that may be limiting this goal.

Mentor Involvement

Gender gap research explored mentors' effect on women's views of engineering careers. Studies show that the absence of role models for female students planning to explore non-traditional careers such as engineering hinders the female students' perception of engineering as a career (Cheryan et al., 2011). This is attributed to the idea that before an individual chooses a career, they must anticipate that they will be successful (Cheryan et al., 2011). One way for women to feel as though they can be successful in a career is exposure to a role model or someone who is accomplished in their field (Cheryan et al., 2011). "Interacting with one member of a field, even briefly, can shape students' beliefs about their potential for success in that field" (Cheryan et al., 2011, p. 661). Therefore, students' experiences with mentors involved in STEM related careers can have an effect on their perceived success within that field and are crucial to establish a larger population of those currently underrepresented in the field.

Previous research concluded that mentors in non-traditional careers provide both direct and indirect effects on young female students and are crucial for female success within these careers (Quimby & Santis, 2006). Young female students who observe successful mentors within non-traditional careers are more likely to feel as though they could be successful within a career such as engineering (Quimby & Santis, 2006). Role models and mentors play an important role in students' self-efficacy, as interacting with a mentor working in a career shapes students' beliefs about their potential success in that career setting (Cheryan et al., 2011). Self-efficacy built on relationships resulted in patterns of resiliency as women continued along their academic and career paths (Zeldin & Pajares, 2000). In the study conducted by Zeldin and Pajares (2000), it was evident that factors enhancing self-efficacy beliefs of women in math and science related careers included the confidence that significant people within their lives expressed in the women's capabilities. Mentors allow students to see themselves as capable enough to pursue a non-traditional career. Furthermore, mentors may be able to provide learning opportunities and experiences within engineering, which may increase student interest.

Women, especially those pursuing a male-dominant career, are responsive to encouragement from teachers as mentors (Zeldin & Pajares, 2000). All women interviewed in the study conducted by Zeldin and Pajares (2000) described teachers who were influential to the development of their career choice. Instructors, teachers and professors act as mentors and play a huge role when persuading students to continue taking courses in STEM. Carrington, Tymms, and Merrell (2008), concluded that gender of the mentor was perceived to be relevant to students. Female students majoring in areas such as physics, computer science, and engineering who had female instructors were less likely to continue taking courses in that area of study (Bettinger & Long, 2005). Therefore, although it is important to have a mentor, female students pursuing an engineering career communicated that female role models did not have as large of an impact as male role models when influencing them to continue in that field (Bettinger & Long, 2005). In fact, women participating in the study conducted by Zeldin and Pajares (2000) described male teachers that were especially influential to their career choices, and one woman communicated that she found her male professors much more influential than her female professors. Although not all women in this study mentioned male role models, it was agreed upon that “women felt that teachers’ influences were effective because of the teachers’ enthusiasm for the subject matter and because of their passion regarding the success of women in the male domains” (Zeldin & Pajares, 2000, p. 232). Although many women within previous research have mentioned male role models, it is unclear whether or not that is because of male-dominance within STEM fields or because those males serve as better mentors.

Although gender of the mentor seems to have an effect on students’ perceptions of success, gender gap research has concluded a few different, opposing ideas when investigating mentor involvement in women’s retention in STEM careers. When conveying to women their potential success within STEM careers, role model gender may be less important than the extent to which role models embody STEM stereotypes (Cheryan et al., 2011). In a study conducted by Cheryan et al. (2011), gender of the mentor and stereotypical STEM role models were explored as variables that might affect women's attrition in STEM related careers. The authors found that women believed they would be less successful in a computer science career after interacting with a stereotypical role model rather than a non-stereotypical role model (Cheryan et al., 2011). Stereotypical and non-stereotypical role model traits were decided on by a pretest given to students participating in the study. Stereotypical computer science traits included glasses, a t-shirt with a computer science related slogan, unfashionable pants, socks and sandals, playing games, watching anime, programming, watching Star Wars, watching Mystery Science Theater 3000, and receiving an electronic gaming magazine. Non-stereotypical computer science traits included solid colored shirts, fashionable jeans, flip flops, playing sports, hanging out with friends, listening to music, watching American Beauty, watching The Office, and reading Rolling Stone magazine (Cheryan et al., 2011). They concluded that there was no effect of role model gender to women's anticipated success in a computer science career, only the dissimilarities between the women in the study and the stereotypical traits (Cheryan et al., 2011). Furthermore, when comparing participating male ideas to female ideas, male success beliefs were not affected by the exposure to stereotypical role models (Cheryan et al., 2011). This reveals that these stereotypes seem to have a larger influence on women's success than men. With opposing research within this field, more research is needed to conclude whether the gender of the mentor may play a role in female student perceptions of STEM fields.

Family Involvement

Research in family involvement posed an interesting question: do parents influence their children who pursue a STEM career, such as engineering (Sonnert, 2009)? Parents play a crucial role in children's lives from birth to adulthood, including educational aspirations and educational expectations (Swan, 2015). Since parents play a crucial role in their children's lives, parents also conceivably influence decisions such as declaration of college majors and career interests. Recent research explored parent involvement and its relation to the STEM gender gap, in hopes of influencing more students, especially girls, to consider STEM careers like engineering. With a large number of competing influences, it is difficult to draw definite conclusions from the research conducted. Because parents play a variety of roles when it comes to influencing their children, they may have a huge role in promoting engineering careers (Dorie, Jones, Pollock, & Cardella, 2014). By influencing more women to pursue engineering, diversity within the engineering field would increase to better represent the population.

Another important familial dynamic is occupational inheritance. Occupational inheritance refers to children pursuing the career paths of their parent(s), and is often referred to when discussing parental figures promoting engineering (Dorie et al., 2014). Occupational inheritance plays an important role because children of engineers tend to have a better understanding of their parents' occupation, and may develop a more positive outlook on engineering as a career. One result of occupational inheritance may be improved academic achievement because as engineers themselves, the parents are able to better assist with the learning of engineering concepts.

Regarding female interest in STEM and future career interest, parents themselves have a major influence (Sonnert, 2009). Previous research investigated whether or not parent gender played a role in mentoring. Specifically, researchers examined whether fathers or mothers were mentioned as mentors more often by students. This investigation concluded that female engineers tended to rely on opposite sex parental influences, who were often in the same occupation (Sonnert, 2009). By contrast, it was concluded that same sex parental mentors were more beneficial in traditional careers, rather than nontraditional careers (Betz & O'Connell 1992). Traditional careers for women in the past were less physically strenuous than those of men, and often involved care and compassion. Jobs historically considered traditional for women included nursing, teaching, secretarial work, or jobs in which females are not outnumbered by males. Historically, non-traditional jobs included careers where women are outnumbered, and included more intellectual or laborious work.

Data gathered in previous studies confirmed that female scientists were more likely than male scientists to mention a parent as a direct influence on their career choice, and that parent was more often a father than a mother (Sonnert, 2009). The odds of females mentioning a parent as an influence in their science career were 3.5 times higher than men (Sonnert, 2009). An influential father figure was 3.8 times more likely to be mentioned as an influence to these women scientists compared to male scientists (Sonnert, 2009). This may be due to the fact that men, up until this point, are more prevalent in STEM related careers than women.

Women's perceptions of engineering and STEM related careers drastically change when family is involved in a similar career. In a study conducted by Zeldin and Pajares (2000), ten out of fifteen of the women interviewed who were currently employed in a STEM related career provided examples of family members who had modeled skills and provided encouragement that made them feel as though they were capable of a future in that career. For women entering male dominant fields such as engineering, this study showed that "the social persuasions they received from members of their family regarding the idea of women going into male-dominated areas and of women doing what they wanted to do were critical and integral to their later paths" (Zeldin & Pajares, 2000, p. 229). Many of the early experiences in a STEM field were due to family involvement, and interaction with family members (Zeldin & Pajares, 2000). Multiple women within this study described their father's influence on their STEM career choice in detail, and credited him as their primary influence (Zeldin & Pajares, 2000). Parental involvement may take different forms throughout children's lives, but parents who facilitate involvement in math, science, or engineering programs and help their daughters with them may play a critical role in career interest development (Swan, 2015). Swan (2015) suggests that having a parent as encouragement and to assist with math, science, engineering, or design work plays a critical role in engineering interest among young females. Although family involvement and influences can have an effect on female student perceptions of engineering careers, early experiences with engineering in STEM programs may also play a role.

FIRST and Engineering Programs

The FIRST (For Inspiration and Recognition of Science and Technology) program is a STEM program that is designed to give students the opportunity to participate in engineering and computer science experiences (FIRST, 2018). Early experiences, such as these, can have an impact on student perceptions of engineering careers. In this section, information will be provided about what the FIRST program entails, providing background knowledge of the program, along with its goals and mission. A FIRST programs overview will give insights into the sub-programs of FIRST (FIRST Lego League, FIRST Technology Challenge, and FIRST Robotics Challenge). Second, the section "FIRST Impact on Students" explores previous research on the FIRST program and its impact on both male and female students. Last, FIRST impact on female students gives insight into previous research conducted on the impact of FIRST programs on female students.

FIRST Programs Overview

Various studies have examined whether FIRST and other STEM programs lead to higher participation rates in STEM education and careers. Therefore, it is important that STEM programs such as FIRST (For Inspiration and Recognition of Science and Technology) are explored to determine whether they contribute to this goal. When students are engaged in hands-on STEM experiences, they build confidence, grow their knowledge and develop habits of learning. When adults coach these students, they encourage them to problem solve, and connect STEM concepts to the real world. FIRST is a program striving to provide STEM opportunities for both male and female students, allowing them to explore their interests in STEM related fields, in hopes of encouraging them towards careers in STEM (Welch & Huffman, 2011). Strategically, this program promotes problem-solving and critical thinking through broad, open-ended scenarios to engage students (Fletcher & Haag, 2016). In general, all FIRST programs include a combination of robot design, building, programming, a written engineering notebook, and team values (Fletcher & Haag, 2016). Several programs exist within FIRST, including FIRST Technology Challenge (FTC), FIRST Robotics Challenge (FRC), and FIRST Lego League (FLL).

The higher level programs within FIRST are FTC and FRC. At the beginning of the robotics season, a robotics challenge is released by the FIRST Company as a large, nation-wide kickoff (FIRST, 2018). Within the challenge presented to students involved in FTC and FRC, there exists a "mission" that has a specific game or theme. Students must construct their robot to complete the "mission" and score points. Missions include challenges that range from easy to difficult, to engage all levels of students in the engineering design process (Fletcher & Haag, 2016). The engineering design process includes building, testing, programming, and analyzing the robot while recording the process in a written journal. FIRST provides interesting themes and technical scenarios, which helps students engage in engineering practices and use critical thinking strategies to solve the challenge problems (Fletcher & Haag, 2016). Although there are many similarities between FTC and FRC, there are a few main differences that make the programs very different in rigor.

FTC teams are relatively small, consisting of up to 15 team members, grades 7-12 (FIRST, 2018). Any student of any ability level is encouraged to participate. This program allows students to get experience in all aspects of designing, building, and programming the robot, with changes and updates to the robot allowed throughout the entire season. All skills are welcomed, including fundraising, team building, outreach, public-speaking, web-design, videography, photography, and many more. Teams are guided by adult coaches and mentors, allowing students to develop STEM skills, practice the engineering design process, and practice engineering principles. Coaches and mentors meet with FTC students at least once per week throughout the robotics season. This program also hopes to encourage students to see the value of hard work, innovation, and working as a team (FIRST, 2018).

FIRST states that first year FTC teams generally begin by buying a robot kit through the FIRST program (2018). This robot kit is reusable from year to year and can be coded using a variety of Java-based programming. The standard kit comes with a variety of robot parts, game rules and robot rules issued by FIRST. Budgets for teams are generally on the lower side. FTC team registration costs approximately $275 each season. A beginning FTC team can expect to spend around $2,300 for team registration, a beginning robot kit, event registration, travel, and additional costs. Since the robotics kit is reusable each season, veteran teams can expect to pay much less than beginning teams. Students are encouraged to participate in outreach throughout the season, to teach the community and youth about FIRST programs. Outreach allows students to raise funds, design and market a team brand, and earn awards at FIRST competitions such as college scholarships.

The FTC season generally starts in May, where teams begin to form and registration begins. A large season ‘kick-off’ happens in September, when the season challenge is announced (FIRST, 2018). After the kick-off, students can begin brainstorming ideas for the robot. The design and build season lasts approximately 5 months (September through January), and competitions can last well into April depending on the state (FIRST, 2018). Competitions are organized in an alliance format, and begin with league-level tournament play. Each season concludes with regional championship events, with the ability to advance to higher level competitions. If teams compete well at State and Regional Tournaments, they are able to advance to Super-Regional Championship Tournaments and FIRST Championship (FIRST, 2018). Besides competitions, there are many off-season events in which teams can develop their skills, learn new technology, and meet other teams.

Compared to FTC, FRC more rigorous. Many high school student participants describe it as, “the hardest fun they’ve ever had” (FIRST, 2018, para. 1). The FIRST program describes FRC as “the excitement of sport combined with the rigors of science and technology, the ultimate sport for the mind” (FIRST, 2018, para.1). To participate in this sport, teams must have a minimum of 10 students, but can support many more depending on available adult coaches and mentors (FIRST, 2018). Coaches and mentors are generally professionals in STEM or STEM teachers. Many more students are able to participate in FRC because there is no definite team cap, as students can specialize in any job the team needs accomplished to succeed. Many different jobs are available based on the student's skill level or interests. Specific jobs may include robot design, programming, business strategy, team branding, marketing strategies, web design, public speaking, presentations, etc.

A first year FRC team would begin by buying a robotics kit including a common set of game rules and robot parts. FRC teams must meet in a suitable space that is capable of housing an industrial sized robot (approximately 150 pounds) and that has access to machine shop power tools. Annual fees for team registration, the beginner robotics kit, and event participation can range from $5,000-$6,000 (FIRST, 2018). Additional costs can be expected to cover travel to events.

FRC teams generally form and register in the fall, with the official season beginning in January. In January, the season's challenge is announced in an exciting, nation-wide kick off ceremony. The kick-off kick starts an intense six-week build time with strict rules and limited resources (FIRST, 2018). Students design, build, program, test, and make changes to a robot to allow it to play a challenging field game against witty and like-minded competitors. Throughout this six week build session, students are also challenged to raise funds, design a team brand, and enhance teamwork skills. FIRST describes FRC as "as close to real-world engineering as a student can get" (FIRST, 2018, para.1). Professional coaches and mentors guide the team through the robot design process to prepare for competition events. Teams generally meet several times per week during the build and competition season, often working for many hours at a time. During the intense build season, many teams may also meet late into the evening or on weekends. After the six week build season, District and Regional competitions start in February and continue through April (FIRST, 2018). Many FRC teams also participate in off season events to participate in outreach, strategize for upcoming seasons, sharpen their skills, learn about new technology, and meet other teams. Many advanced teams may meet throughout the school year and summer as well.

FIRST LEGO® League (FLL) is a lower level of FIRST, and engages students ages 9-16 (FIRST, 2018). Beginning teams will purchase a standard Challenge Set and a common set of challenge rules issued by FIRST and LEGO® Education. New teams can expect to spend approximately $800 on team registration, the Challenge set, and a kit of parts (FIRST, 2018). Similar to FTC and FRC, veteran teams will pay less each year, since the robotics set can be reused. Team registration fees and new challenge sets must be purchased each year. The FLL season generally begins in August, when the challenge information is released. Registration and team formation usually takes place between May and October, with the build season beginning once the challenge is released. At a minimum, competitions between about 8 weeks after the challenge release date. If teams compete at a high level, they are able to earn spots at the FIRST Championship, which takes place in April (FIRST, 2018). Similar to FTC and FRC, teams may participate in off-season events to help sharpen their skills.

The main vision of all FIRST programs "is to inspire young people to be science and technology leaders and innovators, by engaging them in exciting mentor-based programs that build science, engineering, and technology skills, that inspire innovation, and that foster well-rounded life capabilities including self-confidence, communication, and leadership" (FIRST, 2018, para. 1). Throughout all FIRST programs, students engage in engineering practices, and coaches or mentors assist students in the analysis process (Fletcher & Haag, 2016). Much of what all levels of FIRST promote is working as a team throughout this process and encouraging respect between students and teams. Therefore, through these problem-based experiences, student success in engineering is attributed to their preparation for success in FIRST programs (Fletcher & Haag, 2016).

FIRST Impact on Students

Elementary, junior high, and high school STEM programs were created to encourage more students, including females, to become more interested in STEM. The goal of these programs, such as FIRST Robotics, is to provide opportunities for young individuals to get involved with STEM, in hopes of encouraging them towards a career in a STEM field such as engineering (Weinberg, Pettibone, Thomas, Stephen, & Stein, 2007). The goal of programs such as FIRST Robotics is to help students realize their abilities and find interest in a future career. These programs not only encourage students to pursue a career in engineering, but research concluded that these programs also make students feel as though they could be successful in an engineering career (Weinberg et al., 2007).

Students have a higher interest in STEM fields after participation in STEM based programs such as FIRST Robotics (Welch & Huffman, 2011; Weinberg et al., 2007; Swan, 2015). Welch and Huffman (2011) showed that students who participated in a FIRST Robotics program had a positive outlook on the social implications of STEM, on STEM as a whole, and the important role that STEM plays in our everyday life. These students also had a positive outlook on STEM professionals working in the community, and a positive outlook on scientific inquiry (Welch & Huffman, 2011). Swan (2015) concluded that experiences related to engineering, such as involvement in programs like FIRST, are an important factor in participants' development of interests in engineering. Melchior, Cohen, Cutter, Leavitt, and Manchester (2005) found that students who participated in FIRST Robotics were "more than twice as likely to expect to pursue a science or technology career (45% vs. 20%) and nearly four times as likely to expect to pursue a career specifically in engineering (31% vs. 8%)" (p.6). Therefore, involving students in these types of activities is an effective way to introduce these students to engineering and spark interest (Swan, 2015). Programs like FIRST Robotics provide opportunities for students to build a better understanding of STEM careers, and build a positive outlook on STEM related fields and science in general. These programs shape student beliefs about their ability to be successful in a STEM related career. Therefore, from the student perspective, these programs improve students' outlook and attitude towards science.

Fletcher and Haag (2016) studied the perspectives of FIRST mentors and coaches. From coaches' and mentors' perspectives, participation in a FIRST program sparked student's interest in STEM careers and provided awareness of how science and math are used in the world. According to Fletcher and Haag (2016), coach and mentor responses also indicated that student skills, interests, and abilities increased throughout the program. Coaches described that students felt more of a sense of belonging when being involved on a robotics team (Fletcher & Haag, 2016). Participants indicated that they also felt this sense of belonging, and felt as though their skills were strengthened throughout the season (Fletcher & Haag, 2016). This shows that FIRST may promote a sense of belonging, and may heighten students' overall self-efficacy.

FIRST Impact on Female Students

Weinberg et al. (2007) explored whether or not programs such as FIRST robotics help to close the gender gap. STEM programs may reduce the gender gap, as they may alter student beliefs that they are able to be successful in a STEM related career (Weinberg et al., 2007).

Although many students in FIRST Robotics have a positive perspective on STEM careers, female students are especially impacted by this program. A developmentally appropriate robotics program can be an effective way to introduce young girls to engineering components of STEM (Sullivan & Bers, 2016). Increased evidence suggests that a number of external factors influence female opportunity to learn and participate in STEM activities, which may predict continued involvement in STEM fields. According to Witherspoon, Schunn, Higashi and Baehr (2016), female student involvement in programs such as robotics competitions may lead to increased female motivation to pursue additional opportunities in STEM.

Research concluded that FIRST Robotics has an impact on female student educational decisions after leaving the program. Female participants were significantly more likely to declare engineering majors or expect to enter an engineering career than female students in a comparison group who were not involved in a FIRST program. (Melchior et al., 2005). FIRST alumni tend to have high interest in computer science, engineering, and robotics. Research completed by Burack, Melchior, and Hoover (2018) concluded that students tended to be approximately twice as likely to be interested in computer science and engineering, and almost 4 times as likely to be interested in robotics. Furthermore, a large percentage of FIRST female alumni continue to take STEM courses and go into a STEM related job. Compared to a group of students who were not involved in FIRST Robotics, females majored in engineering at comparatively high rates, as 33% of the female FRC alumni majored in engineering (not including computer science) after being involved in FIRST Robotics, whereas 2% of the comparison group majored in engineering (Melchior et al., 2005). Among first-year college students, FIRST alumni reported significantly higher interest in majoring in computer science and engineering in college (Burack et al., 2018). It is difficult to assume that these statistics are due to participation in FIRST Robotics alone, however, since many students who participate in FIRST are already interested in STEM.

In a study conducted by Swan (2015), girls in a postsecondary engineering program were interviewed about experiences that led them to pursue their career. Participants identified enjoying science and math classes, and engaging in math or science activities that had supported their self-efficacy within engineering. Some of these programs and activities started in elementary school and continued into high school. Students revealed in interviews that participation on a robotics team led to their interest in engineering. Therefore, experiential learning fosters career interest, technical skills, and inspiration to pursue engineering in college. Involving young females in these types of activities is an effective way to introduce these students to engineering and spark interest (Swan, 2015).

Summary and Research Questions

Previous research points to many variables that affect women's desire to pursue engineering as a career. Some of these variables include personal beliefs about ability (Zeldin & Pajares, 2000; Cheryan et al., 2017), mentoring (Quimby & Santis, 2006), family involvement (Sonnert, 2009), and early engineering experiences (Cheryan et al., 2017). Early engineering experiences include programs such as FIRST Robotics, which aim to provide encouragement and heighten self-efficacy (Welch & Huffman, 2011). This study will build on previous research concerning the underrepresentation of women within the field of engineering. More specifically, this study will explore the gap present in previous literature concerning the relationship between family involvement, mentoring in early experiences, and perceptions of engineering careers. Based on previous research, the following research questions will be investigated in this study:

1. How do female student perceptions of engineering careers change when they are involved in a FIRST Robotics program?
2. How do female FIRST Robotics students' perceptions of engineering careers change when a parent figure is involved in FIRST Robotics as a mentor compared to those who do not have a parent figure involved?

Theoretical Framework

Social Cognitive Career Theory

Social Cognitive Career Theory (SCCT) is rooted in Albert Bandura's Social Cognitive Theory. Social Cognitive Theory (SCT), according to Bandura, articulates the effect of social practices on one's development (Bandura, 2011). Social Cognitive Career Theory explores ways in which interests are formed, choices are made, and how that correlates to success in occupation (Lent, Brown, & Hackett, 2000). SCCT focuses on many different variables of one's social environment and their interactions. These variables include self-efficacy, outcome expectations, and personal goals that may help shape the course of career development (Lent et al., 2000).

> "SCCT focuses on the interplay of environmental and behavioral variables that influence the way that students: (1) develop academic and career interests, (2) make and revise their educational and vocational plans, and (3) achieve performances of varying quality in academic and career pursuits." (Lent, Lopez, Lopez, & Sheu, 2008, p. 53)

Interests in closing the gender gap in engineering careers has provided interest in SCCT and its relation to attracting students to these fields (Lent et al., 2000; Lent et al., 2008).

Many factors, including important people in students' lives, can affect interest in careers. Lent et al. (2000) explored environmental influences including career role models in academic and extracurricular activities, and found that social environment has a direct correlation to career choice. In other previous studies, similar factors were shown to influence career choices: (1) perceived support from fathers (McWhirter, Hackett, &

Bandalos, 1998), (2) faculty support and encouragement (Hackett, Betz, Casas, & Rocha-Singh, 1992), and (3) teachers, parents, and friends (Fisher & Stafford, 1999). Although student interest does play a role in career choice, it is accepted that social influences such as family involvement and mentors appear to also influence career choices. In some cases, social environment, social influences, family, and mentors may play a larger role than the student's own interests. For example, Tang, Fouad, and Smith (1999) concluded that within a sample of Asian American college students, both family involvement and self-efficacy played a larger role than one's own interests when it came to career choice and success. Self-efficacy refers to one's beliefs in their ability to perform actions or tasks (Bandura, 1997). Social environment and self-efficacy research, along with their relation to SCCT, may help to explain the gender gap and why women tend to be deterred from male-dominant careers like engineering.

This study will explore FIRST robotics and parent mentors as variables in students' social environment, and their effect on students' perspective of engineering as a potential career. SCCT theorizes that students are more likely to develop interests in activities, academics, and careers when they have a high sense of self-efficacy (Bandura, 1997). Students develop this self-efficacy by actively engaging in some sort of experience or activity. Through these self-efficacy building experiences, they begin to develop more interest in specific activities that they feel good at (Bandura, 1997). Therefore, since this model shows how interests develop through environmental factors such as self-efficacy building activities, this theory supports the research study at hand. In order to explore these experiences, a qualitative research approach is most fitting. More research into the self-efficacy beliefs of females involved in these activities, along with other social environment factors that may affect their career choices, may give insights into the gender gap within engineering. Therefore, Social Cognitive Career Theory will act as the foundation for this study, as similar variables will be explored. These variables and the model for the theory will provide a framework for both the methodology and the data analysis.

CHAPTER 3

METHODOLOGY

Population

The population studied included middle school and high school age (12-18 year old) female students involved in two FIRST Robotics Challenge (FRC) teams in two rural towns (with populations of approximately 3,000 and 1,795 people) in Iowa. The FRC teams that the female student participants compete with are from two different school districts; one team is sponsored by the school, the other is not. These teams average approximately 15-20 students per team per year. Typically, these teams tend to be approximately 30% female and 70% male. The studied population included all female students participating in the FIRST Robotics teams that participated. These students included female students who had a parent mentor involved in FIRST Robotics as mentors, and female students who did not have a parent mentor involved. In this study, a parent mentor is defined as a figure involved with a FIRST Robotics team, that is of parental relation to the student (stepfather, father, stepmother, or mother).

Role of Researcher

As the researcher, I am connected to participants in FIRST because I coach an FTC team in the Cedar Falls Community School District, which was not a participating district in this study. From previous observations and experiences with my students, I noticed positive outcomes from mentoring, by parents and others, within this program. Therefore, I have an interest in father mentoring and whether or not it has a positive impact on young female robotics students and their perceptions of engineering careers.

As a female involved in a STEM career, I have an increased insight about how women perceive STEM careers. However, my position may prove to add bias to my interpretations. I am also a female in a non-traditional field of study, as I teach both physics and chemistry.

My connection to this study stems mostly from the pursuit of my career. Although I pursued a teaching career in college, which is considered a traditional field for females, the content area that I chose to teach was non-traditional. Since I pursued a non-traditional teaching career for females, I found myself among many men in my content classes at my undergraduate institution. Throughout my content classes, I felt underrepresented and overlooked by my peers because I was female. Although I felt some of this bias, my love for the content in which I studied pushed me to become a teacher and connect with youth. Connections with youth and my love for STEM helped me find a passion for STEM programs such as FIRST Robotics. I was approached by a colleague and asked to coach an FTC team for the district and have loved working with the students on my team. I have been in the FIRST program setting 1-2 times per week for the first 4-5 months of the school year for the past 2 years, and have worked with some of these students previously. This led me to become passionate about promoting female representation within non-traditional careers such as engineering and STEM programs such as FIRST.

Focus

The basis of this study lies in Social Cognitive Career Theory (SCCT). SCCT explores variables that may affect career development and how those variables are related. These variables can be grouped into three major categories; 1) how academic and career interests develop, 2) how academic and career choices are made, 3) and how academic and career success is achieved (Lent et al., 2000). Many variables, such as social environments, interactions, self-efficacy, and personal goals are at play when exploring interests and choices. These variables play key roles in SCCT, and therefore must be examined when exploring career interests and choices. Based on the variables creating the model for SCCT, this study will focus on female student perceptions of engineering as a career. With a variety of variables intertwined and select variables held constant, this study lends itself best to a qualitative research approach, as it attempts to gain insight into women's reasoning, opinions, and explore motivation behind why women may or may not want to pursue engineering. The qualitative study will involve questionnaires and interviews with students, in hopes of capturing some of their feelings and experiences that help shape their perceptions of engineering as a career. The qualitative approach is also preferable as it expresses richer detail from the small number of interviews, some of which might be lost if the data were translated into entirely quantitative representations.

Recruitment

After Institutional Review Board approval (IRB 19-0008), recruitment for this research project began at the beginning of the school year (August 2018) and continued into the beginning of the FIRST Robotics season (October 2018). Iowa FIRST Regional Coordinators were provided with a coach recruitment script (Appendix A), who in turn distributed it to the FIRST coaches (FLL, FTC and FRC) in the region targeted via email.

Since all of the coach information is confidential, the specific number of coaches that were contacted was not provided to the principal investigator by the FIRST Regional Coordinators. This recruitment script informed the coaches of the research focus, along with an explanation of the generic FIRST surveys coaches would give to their FIRST teams if they chose to participate. If coaches were interested in participating in the study, they were provided with the researcher's contact information. Only two coaches contacted the principal investigator to voice interest. Once contacted, meetings with the two participating coaches were arranged to explain the study and how the research would be conducted. If the interested coach was a part of a team that was associated with a school district (one of the two coaches), a Letter of Cooperation (Appendix B) was sent to the school district's superintendent to give permission for the team to participate. Coaches were also informed that they would be able to see the pre and post season survey results as a way to better prepare themselves to coach during the upcoming 2019 FIRST season.

Data Collection

In this study, data was collected using a pre and post season questionnaire and interviews, where survey questions were used to shape the questions for the interviews. To explore feelings and ideas of potential participants at the beginning of the FIRST season, a preseason survey was given to all FIRST female students on teams of participating coaches. In order to target female students that have never been involved in a FIRST Program, this survey was given at the beginning of the school year, when students received their FIRST Robotics team assignments. The intent when the research was designed was to gauge female student thoughts and feelings before becoming involved in FIRST Robotics, to help better understand how their feelings changed throughout the program. However, all of the female members of the two teams participating in the research project had previous FIRST experience.

A narrative was read to students (Appendix C) to introduce the surveys and research to their team. This narrative explained that this survey was a generic survey given to all students, but only female students would be able to partake in research. Female students who were interested in participating in the research and having their answers further analyzed were given parental permission forms/assent forms.

The initial survey (Appendix D) was a 15-20 minute survey that consisted of questions targeting feelings toward engineering as a career and self-efficacy beliefs of students. These questions were framed using a Likert scale, where students could indicate a degree of interest pertaining to each question. SCCT explains how student beliefs about themselves may contribute to interest in a career. Therefore, it was important that we gauge how students felt about their ability.

Interested female students (13 total) on the two participating FIRST teams brought back signed parent permission forms/consent forms (Appendix E) to participate in the research study. Surveys and permission forms/consent forms were collected by the principal investigator from the two coaches of the two participating teams after the surveys were given. Survey results were collected and analyzed. Surveys were anonymous, and were coded with student pseudonyms. Student pseudonyms were created by the participants by indicating their birthday, number of siblings, birth month and favorite color. All females who participated in the survey consented to having their answers analyzed.

There were approximately 38 student surveys collected; 13 from female students and 25 from male students. Only female surveys were included in research and further analyzed. Anonymous survey answers were made available to coaches to view via Google Sheets after the FIRST robotics season was complete. After survey results were analyzed, additional interview questions were formed based on female student answers.

At the end of the season, coaches read an additional narrative that re-explained the research that was taking place. All students took the generic post-season survey (Appendix F). All female students who returned consent/parental permission forms at the beginning of the season had their post season survey answers analyzed.

This survey took approximately 15-25 minutes for students to complete. Questions targeted how students felt about engineering as a career after being involved in a FIRST program. Survey questions also asked about self-efficacy beliefs, mentors, and how students' felt those mentors within their lives have changed their perceptions of engineering. Based on the post-season survey, female students who expressed interest in participating in interviews were contacted based on the student/parent emails provided on the consent/parent permission forms.

Females who chose to have their answers further analyzed for research purposes consented to do so on the parent permission/consent forms. Surveys were given to the students by the coaches in the FIRST program environment or setting that was individual to each school and team.

Interviews

A set of semi-structured interview questions were formed prior to students taking the pre and post season surveys (Appendix G). Interview questions targeted specific areas of Social Cognitive Career Theory such as self-efficacy, family involvement, and mentor impact on student perceptions of careers. From collected pre-season surveys of students expressing interest in an interview, more interview questions were formed to gain deeper insight into student responses. Questions that were formed included questions asking for more information about specific responses on the survey, such as words describing an engineer, experiences contributing to interest in engineering, etc. Many students were very short and concise with many survey answers, so in some cases, more information was needed. Based on student interest, students were contacted about participating in an interview.

Out of the six female students who expressed interest in an interview or requested more information, only one student chose to participate. The interview was conducted by the researcher, and was audio recorded as the interview took place. At times, interview responses led to questions that were not originally part of the script.

The interview was conducted at a public library of the participant's choosing, depending on what worked best for the student/parents. The location did not single out the student as a participant, as coaches and peers were not notified of the student being interviewed in any way. After the interview was completed, the interview recording was uploaded into the online transcription service, NVivo Transcription.

Data Analysis

After completion of the data collection, data analysis took place to determine whether or not the introduction of FIRST programs or mentoring demonstrated an impact on middle to high school aged females and their perceptions on engineering careers. There were thirteen female students that participated in both pre and post season surveys and seven female students that participated in only pre-season surveys. The seven female students that participated in pre-season surveys but did not participate in post season surveys may have decided to not continue with the FIRST robotics program or may have been absent on the day of the post season survey. Their surveys were not included in the data analysis, as changes in ideas throughout the robotics season could not be explored. Survey answers were typed into an Excel Spreadsheet and uploaded into the qualitative analysis software, NVivo.

Time was taken to simply read through the data collected by the surveys, to become familiar with the information collected. When skimming the data, notes were taken about patterns, similarities, relationships, and frequency in statements. After becoming familiar with the data and concluding what general ideas the participants were expressing, notes about patterns and relationships within were turned into summative statements about the data, known as codes. These codes were entered into the qualitative analysis software to establish themes within the data. Some codes within the data included engineering interest, positive parent mentor experience, positive engineering ideas, no engineering interest, no parent mentor experience, etc. After applying codes to the data, the data was organized to examine and analyze the ideas in a structured manner, and to establish any connections between information.

After the interview took place, the data was read and examined to conclude what general ideas the participant was expressing. While reading the data, notes were taken over general patterns, trends, relationships, and frequency in statements. These notes were turned into summative statements that gave a better insight into what themes were present within the data, known as codes. These codes were compared to codes present within the survey data. Any codes that were not repeated from the survey data to the interview data were used to deductively analyze the transcript, to make sure no major themes were missed. The interview was uploaded into the online qualitative analysis software NVivo Transcription to be transcribed. After transcription, the document was uploaded into the qualitative analysis software NVivo to be analyzed further. Codes were entered into the qualitative analysis software to establish themes within the interview data. After applying codes to the interview, the information was organized to examine and analyze the ideas in a structured manner. Relationships within the interview were examined further to establish connections between the data. After the information was coded, a list of all topics was made, and similar topics were clustered together. The data was assembled and a preliminary analysis was performed. Themes were interconnected into a storyline to add to previous research on the topic.

A significant gap in the research exists in the aspect of family involvement, and its impact on female student perceptions of engineering careers. In this study, student perceptions of mentoring within a STEM Program by a parent figure was explored, with the expectation that it will add to previous research conducted on family impact on career aspirations of female students.

CHAPTER 4

RESULTS AND DISCUSSION

Survey Results and Discussion

The survey was administered at the beginning of the FIRST Robotics season during the 2018-2019 school year. The participating coaches administered the surveys at one of the first team practices of the season. The following tables display the results of the pre and post season surveys. Table 6 shows student responses at the end of the FIRST Robotics season, whereas Table 7 shows the changes in answers from pre to postseason.

Questions were framed with Likert scale interest/confidence responses. Students could rate interest/confidence as strongly disagree, disagree, undecided, agree, and strongly agree. In Table 7, changes in student responses were recorded as an increase, decrease, or unchanged interest/confidence. An increase was measured as a student moving from left to right, any number of steps, on that scale. A decrease was measured as a student moving their response from right to left, any number of steps, on that scale. Answers from preseason surveys were compared to answers from postseason surveys to determine the increase, decrease, or unchanged interest/confidence. Questions about interest in engineering and confidence to be an engineer were explored, to distinguish the difference between students who simply had an interest in engineering and those who were interested in pursuing a career.

Table 6

Female Student Responses on Post Season Survey

	Female Student Responses		
Survey Question	Agree/Strongly Agree	Undecided	Disagree/Strongly Disagree
I am interested in engineering.	31%	23%	46%
I am confident I could be an engineer.	54%	23%	23%
I am interested in a career that involves engineering.	23%	54%	23%
I am confident I could do a career involving engineering.	62%	23%	15%
I am interested in computer science.	23%	38.5%	38.5%
I am confident I could be a computer scientist.	23%	46%	31%
I am interested in a career that involves computer science.	23%	54%	23%
I am confident I could do a career involving computer science.	23%	46%	31%

From the data shown in Table 6, there seems to be a gap between female students who are confident that they could be successful as an engineer, and female students who are interested in engineering. After analysis of these four questions, female student interest in engineering seems to be relatively low (31% - interest in engineering, 23%- interest in a career involving a facet of engineering) versus female student confidence to be successful as an engineer (54%- confident they could be an engineer, 62%- confident they could do a career involving a facet of engineering). One limitation of this data might be that engineering and examples of these types of careers were not defined to students. Some students may not know much about engineering, let alone careers that are engineering related.

Social Cognitive Career Theory research concluded that students are more likely to develop interests in activities and careers when they have a high sense of self-efficacy, or confidence that they can be successful (Bandura, 1997). Therefore, from data from many previous studies, it is believed that the gender gap in engineering and other STEM related careers may be related to low sense of self-efficacy (Zeldin & Pajares, 2000; Cheryan et al., 2017). The gap in this study suggests that many female students may be confident that they could be successful as an engineer, they are just simply not interested in a career in engineering. This is contrary to previous research, which concluded that women may be less represented within engineering because of gender gaps in self-efficacy (Cheryan et al., 2017). Another reason may be that self-efficacy is still playing a part, but that female students are feeling more confident in areas other than engineering.

To explore this idea further, a scatter plot of answers to these two questions were formed to investigate whether or not students were answering similarly to these two questions (Figure 1). In Figure 1, student answers for each question were plotted on the Likert scale provided on the survey, one being strongly disagree and five being strongly agree. Student responses to the statement, “I am interested in engineering,” were plotted as x values, while student responses to the statement, “I am confident I could be an engineer,” were plotted as y values. A linear trend line was added to the data, and the coefficient of determination (R^2) value was calculated. This value indicates variance in the dependent and independent variable. An R^2 value that is closer to one shows a strong relationship between variables, whereas a value closer to zero indicates a weaker relationship. This data was plotted and the R^2 value was analyzed to see how closely student interest in engineering was related to student confidence to be an engineer.

Of the female students surveyed, five indicated that they had no interest in engineering, but indicated that they were confident that they could be an engineer or were undecided about their confidence. Six of the female students indicated the same degree of interest/confidence for both questions. Two of the female students indicated that they did not feel confident they could be an engineer, but were interested in engineering or undecided about their interest. From the R^2 value calculated, there is a very weak relationship between interest and confidence in female students. This means that from the collected data, it seems as though female students’ interest and confidence is not the same, when asked what their opinions are of engineering.

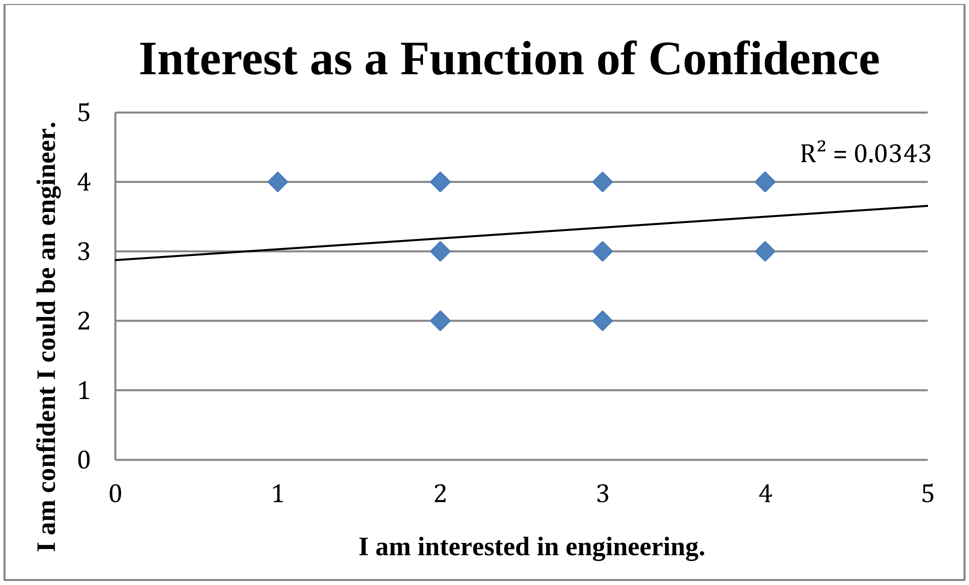

Figure 1. Female student interest in engineering as a function of student confidence to be an engineer.

A similar scatter plot was formed with student responses to the following statements: “I am interested in a career involving engineering,” and “I am confident I could do a career involving engineering.” Similarly, differences in student answers were analyzed to see how student interest compared to student confidence. Five female students indicated that they had no interest in a career involving engineering, but agreed or strongly agreed that they had the confidence to do a career involving engineering. The remaining eight students responded with the same answer to both statements. Although the statements compared in Figure 1 and Figure 2 are very similar, it was intriguing that students did not respond similarly to these questions. The R^2 value was less than that of Figure 1, which means that the relationship was much weaker. Students that are interested are not confident, or vice versa. One explanation may be that students were not given any example or definition of engineering.

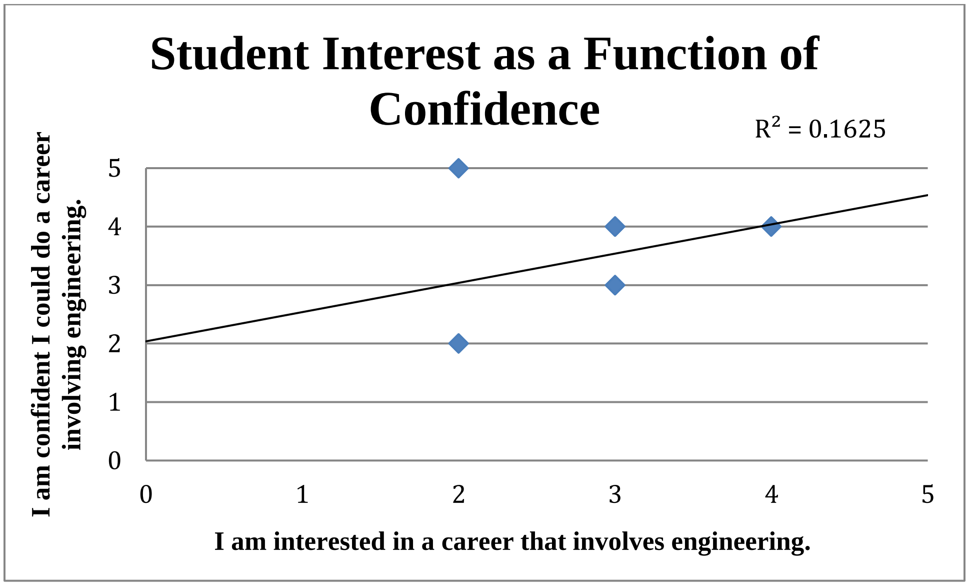

Figure 2. Female student interest in a career involving engineering as a function of student confidence to do a career involving engineering.

Although the sample size is small, this data shows that many female students in this sample are confident that they could be an engineer, but are simply undecided or not interested. As stated previously, this is another piece of data that is contrary to previous research, concluding that self-efficacy was playing a part in female students becoming engineers. Although, more research needs to be conducted with larger sample sizes to explore whether or not this is a generalizable trend.

From the open-ended survey questions on the post season survey, students were asked to provide some careers that they were interested in. From the responses, only one female student explicitly listed engineering as a career of interest. Two other students expressed interest in STEM-based careers, with responses of "something to do with computers" and "something in the STEM field" (survey, 29-2-January-Yellow & 11-2-June-Orange). Other careers of interest included teaching, business, psychology, and early child care. Although only one female student listed engineering as a response, more female students showed engineering interest when asked directly whether or not they were interested in a career in engineering in an open-ended format. Specifically, four additional female students expressed interest in an engineering career after answering this question with the following:

- "Yes because I love the creativity with becoming an engineer and there are many different career pathways." (survey, 24-3-July-Blue)
- "If I got the opportunity I would. I think it would be fun to feel like you're doing something important. I would also love to see the image in your head come to life." (survey, 12-1-March-Lavender)
- "I kind of am, but I'm not really sure yet. I'm still searching for the exact thing that I would like to do." (survey, 11-2-June-Orange)
- "Maybe, I think I'd like to do CAD in the future." (survey, 5-1-November-Black)

These responses show that females who aren't explicitly interested in engineering may still have a small amount of interest to pursue engineering or other related careers. The response from the survey from student 12-1-March-Lavender was especially telling, as it seems as though this student is interested in engineering, but doesn't feel as though the opportunity is there for her to pursue it. It is possible that some other female students also feel this way. It is possible that these female students are more interested in another career path, haven't developed enough self-efficacy beliefs in themselves, or are uninterested for other reasons that need to be explored in further research. Another explanation may be that students simply have not thought seriously about a career at this point in their education.

In various research studies, computer science is considered a facet of engineering. Students were asked similar Likert scale survey questions about computer science interest and careers. These careers and topics were not formally defined to students, and neither were the differences between computer science and engineering. Similar to engineering, one limitation of this data is that computer science was not defined to students. Unlike engineering, where there seems to be a gap in female students' interests and confidence to pursue an engineering career, computer science did not have this interest/confidence gap. Questions assessing student interest/confidence with computer science careers were asked in the same format as the questions regarding engineering, and were written as follows: 1) I am interested in computer science, 2) I am confident I could be a computer scientist, 3) I am interested in a career that involves computer science, and 4) I am confident that I could do a career involving computer science. For all of these questions, 23% of female students agreed (Table 6). This data is very consistent, compared to the data collected for the same questions regarding engineering.

The question still stands, why is this gap so apparent in engineering, but not in computer science? One explanation may be that the students in this FIRST program have a better understanding of engineering as a career, and don't understand computer science quite as well. This would make it particularly difficult to be confident that you could do something, especially if you aren't completely confident as to what the career entails.

Changes in female student interests and levels of confidence were also explored to see how female student perceptions changed throughout the FIRST robotics season (Table 7). With this population of surveyed females, eight out of thirteen surveyed female students had been involved in a FIRST program for two years or more. Five of these female students had been involved in a FIRST program for two years or less. No surveyed female students were brand new to the program. Therefore, none of these female students were coming in with no FIRST experience. Because of this, it was difficult to measure changes in interests, because most students were already aware of engineering and computer science related topics explored through FIRST, and had an idea as to where their interests fell. There was a large portion of the surveyed population of females that rated their interest as undecided.

It is particularly interesting that a large portion of the surveyed population continued to rate their interest as undecided, as data collected on FIRST programs has concluded that students tend to be more likely to be interested in STEM programs after being involved in FIRST. FIRST Robotics programs have been shown to impact female students' educational decisions, as female participants were very likely to declare engineering majors or expect to enter an engineering career after graduation (Melchior et al., 2005). Female FIRST alumni studied in previous research tended to be twice as likely to be interested in computer science and engineering; and a large percentage continued to take STEM courses and go into a STEM related job (Burack et al., 2018). It is unclear why a large portion of the surveyed population is claiming to have a lack of interest or is undecided about their interest in engineering and computer science careers, yet they continue to participate in FIRST programs. One explanation could be that students are enjoying another facet of the FIRST Robotics team, or that they enjoy feeling part of a team.

Table 7

Changes in Interest/Confidence from Pre to Post Season Surveys

Female Student Response Changes			
	Interest or Confidence		
Survey Question	Increase[a]	Unchanged	Decrease[a]
I am interested in engineering.	8%	38%	54%
I am confident I could be an engineer.	15%	77%	8%
I am interested in a career that involves engineering.	0%	54%	46%
I am confident I could do a career involving engineering.	8%	69%	23%
I am interested in computer science.	8%	46%	46%
I am confident I could be a computer scientist.	15%	62%	23%
I am interested in a career that involves computer science.	8%	69%	23%
I am confident I could do a career involving computer science.	8%	54%	38%

[a]*Measurements of interest/confidence were made on a scale, where students could rate interest/confidence as strongly disagree, disagree, undecided, agree, and strongly agree. An increase was measured as a student moving from left to right, any number of steps, on that scale. A decrease was measured as a student moving their response from right to left, any number of steps, on that scale. Answers from pre-season surveys were compared to answers from post season surveys to determine the increase, decrease, or unchanged interest/confidence.*

Although it was difficult to measure, changes in student interest in engineering and computer science were analyzed (Table 7). Student responses to questions were measured on a five point scale, with responses as follows: strongly disagree, disagree, undecided, agree, and strongly agree. An increase in interest/confidence was measured as a student changing their answer any degree, left to right on the five point scale, from pre to post season. An example of an increase in interest/confidence could be a student responding that they are ‘undecided’ whether or not they are interested in engineering on their pre-season survey, and responding with ‘agree’ at the end of the season. A decrease in interest/confidence was measured as a student changing their answer, to any degree, right to left on the five point scale, from pre to post season. An example of a decrease in interest/confidence could be a student indicating that they are ‘undecided’ whether or not they could be an engineer at the beginning of the season, but changed their answer to ‘disagree’ at the end of the season.

The first question asked students if they were interested in an engineering career. Throughout the robotics season, a little over half of these students reported a decrease in interest in engineering (Table 7). It was intriguing to find that a large population of students had a decrease in interest in engineering from pre to post season. The second question asked students to reflect on their confidence to pursue a career in engineering. Throughout the robotics season, three fourths of students believed that their confidence went unchanged, where 15% had an increase in confidence that they could be an engineer (Table 7). Similarly, students were asked about their interest in an engineering related career. Throughout the season, a little less than half of the students believed that their interest in a career involving a facet of engineering decreased, while a little more than half had unchanged interest (Table 7). Lastly, students were asked to reflect on their confidence in pursuing an engineering related career.

Throughout the season, approximately two fifths of students believed that they had a decrease in confidence, while a little more than half of students believed their confidence went unchanged (Table 7). Although there isn't a large sample size, it is intriguing that FIRST participation does not seem to change students' view of engineering and computer science topics and careers. Approximately half of students actually reported becoming less interested in engineering as a career after the FIRST Robotics season. In previous research, evidence suggests that participation in STEM activities may predict continued involvement in STEM fields. Female student involvement in programs such as robotics competitions may lead to increased female interest in pursuing STEM (Witherspoon et al., 2016). Previous research also concluded that female FIRST alumni tend to have high interest in computer science, engineering, and robotics (Burack et al., 2018). Based on previous research, FIRST Robotics programs have been shown to have a positive effect on student perceptions of engineering and computer science topics and careers, which is contrary to the results of this research. Since this study examined a very small sample size, it is extremely difficult to draw conclusions from this data to know whether or not this may be a generalizable trend.

On the pre- and post-season survey, students were also given questions asking them to elaborate on experiences that contributed to their interest, or lack thereof, in engineering. The first asked students to elaborate on experiences that made them more interested in a career in engineering. Female students who reported an increased interest in engineering answered with the following:

- “Yes, being involved in FIRST has helped me become more and more interested.” (survey, 24-3-July-Blue)
- “This, the whole FIRST. I already knew I loved to build and by joining robots I feel like I'm doing the bigger cooler version of LEGOs!” (survey, 12-1-March-Lavender)
- “FIRST.” (survey, 29-1-June-Yellow)
- “Robotics 100%, I learned how to CAD and design.” (survey, 5-1-November-Black)

Second, students that did not find that question applicable and didn’t have an interest in engineering were asked to elaborate on experiences that may have pushed them in the opposing direction. Example female student answers include:

- “I visited ISU and realized how much math there would be.” (survey, 32-2-March-Green)
- “Nothing has ever made me not interested, Mental Health is just more appealing.” (survey, 7-4-April-Grey)
- “Being in the shop building the robot, I like handling the money, making posters, things like that.” (survey, 5-1-September-Pink)
- “Through the process of building the robot and engineering activities I've done through school, I realized that I am just not entirely sure that engineering is the thing for me.” (survey, 11-2-June-Orange)

- "I like marketing better." (survey, 2-4-October-Black)

After analyzing the answers to these female students' questions, it seems as though FIRST has helped with the career decision process, whether females plan to continue with a STEM related career or not. Some female students found that they enjoyed the advertising and marketing facet of the FIRST robotics team. This may include making posters, advertising to local businesses, and participating in outreach. Because they enjoyed this portion of the FIRST program, these students felt as though they didn't want to pursue an engineering occupation, but instead were interested in advertising or marketing. Other female students realized that through building and designing the robot, they may be interested in a career such as mechanical engineering. In other cases, students find that the programming of the robot is most enjoyable, therefore, they believe that computer science may be a good career for them. Other experiences include working with the budget, finances and CAD.

From these responses, it appears that FIRST not only promotes engineering and computer science related careers, but marketing, advertising, and finance as well. These findings agree with Social Cognitive Career Theory, which states that students develop confidence to pursue a specific career by engaging in some sort of experience or activity that relates to that career (Bandura, 1997). Students on FIRST robotics teams are engaging in many different facets of the team, whether it be business, STEM, marketing, advertising, budgets, etc. These self-efficacy building activities are making students feel more confident in their career decisions. Through these self-efficacy building experiences, students begin to develop more interest in specific activities (Bandura, 1997).

Interview Results and Discussion

One student opted to partake in an interview (for full interview transcription, see Appendix H). This interview was conducted at the end of her FIRST Robotics season, in June 2019. This student was a female student who expressed having positive FIRST experiences that helped her find an interest in engineering and computer science topics and careers. Although she did not have a parent serving on her FIRST team as a mentor, she indicated that she had positive mentoring experiences with non-parent mentors serving for her team. She began participating in FIRST Lego League when she was in eighth grade. After participating in FLL for a year, she decided to attend an open house showcasing FTC and FRC. She decided to join FRC, and has been an active member for the last two years. Since she participates on a fairly small FRC team, she has served a variety of roles. One role she discussed often was being a member of the drive team, where she was able to drive the robot at competitions. Another role that she discussed was being elected team captain for the upcoming year.

Throughout the interview, the female student that participated was asked a number of questions about her interest in engineering and its relationship to the FIRST program. She explained that she knew almost nothing about engineering as a career before beginning the FIRST program. She didn't join FIRST because she was interested in STEM, a friend simply told her to join because it was fun, so she did. The only thing she recalled knowing about engineering was "machines." She explained that FIRST opened her eyes to all of the different facets of engineering and computer science, and made her realize that she could be successful in that career, and might be interested in pursuing it.

On the post season survey, this student was asked to write words or phrases that came to mind when they thought of an engineer. She chose “creativity” and “innovation” (survey, 24-3-July-Blue). During the interview, the student was asked to elaborate more as to why she chose these words to describe an engineer. She responded, “when we're out in the shop and we’re starting to build the robot, and sometimes we come across some very interesting problems that you really have to just think out of the box, because everything else you try doesn't work. Just having that open mind, and not being closed minded and just having to try things.” (interview, 24-3-July-Blue)

From this student’s perspective, it is very clear that the team environment within FIRST promotes creative thinking, problem solving and innovation. From these skills, this student became a better thinker and problem-solver. This student related these skills directly to careers in engineering.

After discussing these skills, the student was also asked if she believed she could be successful as an engineer, and if so, why she believed that she could be. She responded,

> I think I could. I think that going through FIRST has prepared me with a lot and I still have two more years to go. I can definitely learn a lot more. I think that if I wanted to continue to pursue software as well, I could definitely keep expanding my mind and get into a good job with that. A lot of the seniors that graduate end

up helping at like John Deere and getting into that and they've almost all gone into some type of engineering career... I'm just going through each year and seeing all the different things they can do, like OK this is programming, that's CAD, and then you can kind of look into more engineering jobs and if there's something you want to do there is definitely a good job out there that can relate to it. It [engineering] is just almost unlimited" (interview, 24-3-July-Blue).

After mentioning that FIRST was something that helped her expand her mind, she elaborated a bit more about how FIRST specifically played a role in her engineering interests, "just opening my mind to everything that I wouldn't have tried if I wasn't in it [FIRST]. I definitely wouldn't have looked at programming and I might have looked into CAD but everything just kind of seemed like, right. But now that I was in it and I kind of had to find something to do and start learning everything, I do actually enjoy this and it's something I could see myself doing" (interview, 24-3-July-Blue).

Team building was also mentioned often in the interview. Many of the team building experiences mentioned weren't aimed at engineering experiences specifically, but were focused on making students feel part of a team and welcomed. The student explained,

"my freshman year we did a group rafting trip and that was one of our first big team bonding activities that year, and that was a lot of fun and it really got us to work together. Right now we're thinking about doing another one coming up either escape room for all of us to think through or for us to do some kind of kickball but there's also just a lot of team bonding when we had this past weekend we took us three captains to Washington D.C. for NAC [National Advocacy Conference] and that was a whole week together going through talking to senators and things like that. So it really brought us together" (interview, 24-3-July-Blue).

The female student elaborated a bit further about her team's role with National Advocacy Conference and its relation to FIRST,

"The main goal was to talk to the senators and representatives of our state and get them to help support FIRST and make sure that they're helping fund it and telling them from a student's perspective how important it is to us that they help with it." (interview, 24-3-July-Blue).

With many team building activities built into her FIRST team, the student elaborated a bit further about how she thought team building helped the students on her team feel welcomed.

"I think it [team bonding activities] really helps especially if you start doing them when a bunch of new students come onto the team so that they can get comfortable with everyone. It's not as pressured as like going straight into the shop and maybe you don't know what you're doing. It's just, hanging out getting to know everyone and making some new friends" (24-3-July-Blue).

Since there was a large mentor presence, a mentor's effect on female student perceptions of engineering careers was explored further in the interview. The interviewee explained the mentor and coach roles on her FIRST robotics team. She explained that her FRC team had five mentors that volunteer their time to help their team be successful. When explaining her experiences with mentors, she emphasized that her team was student led, and mentor guided. This means that students are the primary source of organization and motivation for their team. Students come up with ideas for outreach, organize events, schedule competitions, and come up with a game plan for robot design. Mentors and coaches guide the students to help complete these tasks, wherever they are needed. When speaking about the team's mentors, she mentioned

> "we have two female and three male [mentors]. So three of them [male] work at John Deere and they also volunteer their time to help us. One of them [female] was a teacher and was at our elementary and got into it with her daughter. And then the other one [female] her daughter was in FRC and now that she's graduated she's still stuck around to help the team" (interview, 24-3-July-Blue).

After giving a bit of background information on the team mentors, she explained,

> "our mentors are very, just, they kind of help make the team feel just like a family. I would consider my team and my robotics group like my safe place to go. I definitely feel comfortable if I have something going on to talk to them and it's very just welcoming and they never put you down always trying to help encourage you. They were very strict staying with the whole student led mentor guided and kind of putting you out there to get you to think" (interview, 24-3-July-Blue).

The female student interviewed in this study didn't have a parent mentor serve on her FIRST robotics team, but she did emphasize the important role that parents play in supporting their children and their interests. Although her parents don't work in a STEM field, she explained,

> "both my parents have been really supportive, helping me get to all the different events and making sure that I'm able to get everything done, I need to get done for robotics... They definitely help with different fundraisers and they are very supportive when we do Pizza Ranch fundraisers and stuff like that. They come out and help and try to help spread the word with social media" (interview, 24-3-July-Blue).

Furthermore, even though her parents aren't directly influencing her career choices through their career or mentorship, they are supporting her interests.

Previous research on similar topics to this study supported many of the things that were mentioned by the student in the interview. One major part of the interview was the student describing the mentors' role on her FIRST robotics team, and how they played into student interests in STEM. Many of the things she mentioned agreed with previous research on this topic. Previous research suggests that interacting with mentors working in STEM careers plays an important role in students' ideas about their potential success and their confidence to pursue that career (Cheryan et al., 2011). This is due to the idea that mentors may allow students to see themselves as capable enough to pursue a STEM career, by providing learning opportunities and experiences within engineering, which may increase student interest (Zeldin & Pajares, 2000). The student interviewed described these same ideas, along with describing how the mentors volunteering on their team made it feel like a family. She referenced mentors often within her interview, and emphasized the effect that those mentors had on her and her team. The interviewed student also spoke about her parents, and their influence on her participation in FIRST robotics. Previous research concluded that parents play a huge role in their children's lives, including educational and career aspirations (Swan, 2015). Since parents play a crucial role in their children's lives, parents influence decisions such as and career interests (Swan, 2015). Having her parents as a continuous support system allowed the student to stay involved in FIRST, and allowed her to feel confident in her ability to participate. Lastly, the student accredited FIRST to opening her eyes to STEM, all the career opportunities within STEM, and gave her the confidence to realize that she could do it. (Witherspoon et al., 2016; Sullivan & Bers, 2016; Melchior et al., 2005; Burack et al., 2018).

General Conclusions

Positive FIRST experiences. Through the surveys and conducted interview, it was apparent that positive FIRST experiences were very common within the surveyed population. Some positive FIRST experiences included non-STEM related activities, which included meeting new people, team building, team bonding, gaining meaningful skills, and growing as an individual. Students that expressed interest in engineering or computer science careers related positive experiences, as did other students who were not interested in these types of careers. One student described her experience in FIRST with, "I've met a lot of amazing people through FIRST, and throughout the season I have grown in so many aspects of myself" (survey, 11-2-June-Orange). Another responded, "I really loved it. I liked going to competitions and meeting new people" (29-1-June-Yellow). And lastly, a more descriptive response included, "I had an amazing experience in FIRST this season getting to meet new teams and make lasting relationships with amazing people from all around. I also greatly enjoyed our team bonding moments and getting closer to all my teammates" (survey, 24-3-July-Blue).

Many female students described positive FIRST experiences on the open-ended portion of the post season survey. Some female students described positive technology and engineering-based experiences. These experiences included driving the robot and building the robot. Other students found other facets of the FIRST program more interesting, such as the creativity and innovation behind the engineering and design process. Presentations at competitions were also mentioned as positive experiences for students, as students were able to use creativity and other skills to add to the presentation. One student described bringing their love of singing and acting into one of the competition presentations. Other students tended to focus on the team bonding and team building that happened throughout the FIRST robotics season as their main positive experience. Students described feeling like their teammates and mentors/coaches were like family, which made the STEM experiences much more positive. Teammates helped students feel welcomed into a positive environment, where everyone's ideas were considered and there were no incorrect answers. During the interview, the female student participating in the interview described the FIRST environment as an environment where everyone's ideas are welcomed and considered, because engineers are ones that consider all creative and innovative ideas. "Nothing is really a dumb answer because sometimes one of the most outgoing things can work the best" (interview, 24-3-July-Blue). "Outgoing things" refers to unique and out-of-the-box ideas.

Another positive FIRST experience mentioned by multiple students on the survey was team bonding. Team bonding within FIRST spans more than just building a robot; many FIRST teams partake in other team building and team bonding exercises to bring team members closer together. Team building spans from building robots to advocating for STEM funding to the United States Senate. Team building and bonding within FIRST can be a variety of different activities, but aim to build students' relationships within the team, and build their self-confidence within STEM.

The first research question in this research set out to explore the effect of female student perceptions on engineering careers after being involved in a FIRST Robotics program. Although there wasn't a clear relationship between students who described positive engineering experiences and those who were interested in engineering, based on the data collected, FIRST provides many positive early engineering experiences that may have an impact. Many students who described positive FIRST experiences also had high interest in other careers. Although FIRST provides positive experiences for many female students surveyed in this study, it seemed as though many of the female students surveyed were just simply not interested in engineering.

Parent mentors. Out of the thirteen surveyed female students, four students had parent mentors involved on their FRC team. One female student had both a mother and father mentor, two female students had father mentors, and one female student had a mother mentor. From the open ended survey questions, students were able to explain what experiences they had working with a parent mentor on their FIRST robotics team. A female student with a mother mentor responded, "my favorite memory was when we were in the shop together, and we were trying to figure out the names of the different wrenches that we needed" (survey, 11-2-June-Orange). Another female student explained that her favorite memory with her mother was simply being able to share positive STEM experiences and teach them more about the FIRST program. A female student with a father mentor mentioned, "I enjoyed connecting to my dad through STEM activities and relating FLL to the engineering practices he uses in his career" (survey, 28-1-April-Pink).

When comparing female students who had a parent mentor serve on their FIRST Robotics team to those who did not, one trend that surfaced was that all of the students who did not have a parent mentor had a decrease in interest when responding to the statements "I am interested in engineering," and "I am interested in a career that involves engineering." All students who had parent mentors serving on their teams rated their confidence before the season to their confidence after the season as the unchanged when responding to the statement "I am confident I could be an engineer." These trends are intriguing, because of the incredibly small sample of students who had a parent mentor volunteer on their FIRST robotics team, it is impossible to draw generalizable conclusions as to whether or not the gender of the parent mentor plays a role in student interest in engineering.

Although there was a small population of students that had a parent mentor, the robotics teams that participated in the study had many mentors serving on the teams that were not necessarily related to students. Based on the interview data, the student described that the mentors on her FIRST robotics team were able to give advice, describe experiences, and guide the students on the team. These mentors created positive experiences for this student, and possibly others, on the FIRST robotics.

The second research question explored whether or not female students' perceptions of engineering careers changed when a parent figure was involved as a mentor on their FIRST robotics team. With an extremely small sample population with only a few parent mentors serving on the FIRST robotics teams that were surveyed, the data collected did not allow for adequate answers for this research question.

CHAPTER 5

CONCLUSION

Perceptions of Engineering

How do female student perceptions of engineering careers change when they are involved in a FIRST Robotics program? When drawing conclusions from the data gathered from the surveyed females, after being involved in FIRST robotics female students are mostly confident that they can be engineers, but it seems that the interest is not there to push them to pursue that career. In contrast, although there were less female students interested in computer science overall, female students who were confident that they can be computer scientists were also equally interested in the field. Students that rated their interest/confidence high in engineering were not necessarily the students who rated their interest/confidence in computer science to be high. There was no real trend when comparing the ratings in engineering to the ratings in computer science. It is unclear what may be causing this interest/confidence gap in engineering, but whatever that may be; it doesn't seem to be affecting female students interested in a computer science career.

Self-efficacy refers to one's belief in their ability to perform actions or tasks, and is an essential part of Social Cognitive Career Theory (Bandura, 1997). Previous research that explored women's self-efficacy beliefs, or confidence in engineering, found that self-efficacy may be what is hindering women from going into engineering (Zeldin & Pajares, 2000; Cheryan et al., 2017). Out of many factors that may contribute to women feeling less confident in the pursuit of engineering, previous research identified some common factors that could contribute, one being gender gaps in self-efficacy (Cheryan et al., 2017; Lindemann et al., 2016). In yet another study conducted by Zeldin and Pajares (2000), self-efficacy beliefs were a major factor in helping women select a career in STEM, and verified that experience and persuasion were huge variables in developing and maintaining self-efficacy. Social Cognitive Career Theory suggests that students are more likely to develop interests in careers when they have a high sense of self-efficacy (Bandura, 1997). These conclusions seem to be contrary to the findings of this study, where students participating seemed to feel very confident that they could be engineers, but not interested. This was also very different from the results of the computer science questions, where students believed their confidence and interest was the same.

Secondly, there are a large portion of the surveyed females that are still rating their interest and confidence in engineering as undecided at the end of the FIRST season. Female students that were involved in FIRST for at least 1 year prior showed mostly unchanged beliefs from beginning to end of the robotics season. This could simply be because these female students are familiar with the program, and their interests haven't changed in the last FIRST season. If a population of new FIRST students had been surveyed and initial student beliefs could have been measured, we may or may not have noticed a more significant change in interest.

The interviewed female student believed that her interests in engineering and computer science fields stemmed directly from involvement in FIRST. She claimed to have no engineering experience or interests before becoming involved, and now can see herself pursuing both careers someday. She explained that FIRST opened her eyes to all of the different facets of engineering and computer science, and made her realize that she could be successful and would be interested in that type of career. The team feeling like family, and mentors volunteering their time on her FIRST team helped her feel as though she could do it, and pushed her to continue and be interested in FIRST.

Social Cognitive Career Theory theorizes that students develop self-efficacy by actively engaging in some sort of experience or activity. Through these self-efficacy building experiences, they begin to develop more interest in specific activities that they feel good at (Bandura, 1997). Previous research on FIRST programs has concluded that female students are especially impacted by this program, and that it can be an effective way to introduce young girls to engineering components of STEM (Sullivan & Bers, 2016). Programs like FIRST have been shown to increase female motivation to pursue STEM, including females' educational decisions after being involved in the program (Witherspoon et al., 2016). Female participants were significantly more likely to declare engineering majors or expect to enter an engineering career than female students in a comparison group who were not involved in a FIRST program (Melchior et al., 2005). FIRST alumni are much more likely to have high interest in computer science and engineering (Burack et al., 2018). Furthermore, a large percentage of FIRST female alumni continue to take STEM courses and go into a STEM related job. Although only one student was able to participate in an interview in this study, findings from her interview agree with much of the previous research conducted on FIRST programs. The FRC program that she was involved in was able to heighten her self-efficacy, and open her eyes to all the possibilities within engineering and computer science-related careers.

Impact of Father Mentors

The second research question explored in this study asked specifically about types of mentor experiences on a FIRST robotics team. Directly, this question asked: How do female FIRST Robotics students' perceptions of engineering careers change when a father figure is involved in FIRST Robotics as a mentor? There was a very small population of students that had parent mentors serving on their FIRST robotics team. Since there was such a small population (four students), it was impossible to draw conclusions from the data. From the open ended survey questions, students were able to explain what experiences they had working with a parent mentor on their FIRST robotics team. All students who had parent mentors involved explained positive experiences with those mentors, whether they were male or female. Although there was no difference in responses when comparing female parent mentors to male parent mentors, there was not a large enough sample size to have two groups to compare. All students that had a parent mentor involved on their FIRST team had unchanged views on their confidence to be an engineer from pre to post season.

Social Cognitive Career Theory theorizes that in some cases, social environment, social influences, family, and mentors may play a larger role than the student's own interests (Bandura, 1997). Previous studies concerning family involvement found that women scientists were more likely to be influenced by a father role model rather than a mother role model, especially if that father figure was working in a STEM related career (Sonnert, 2009). Women recalled important parts of their lives, where interactions with family led to self-efficacy building experiences within STEM (Zeldin & Pajares, 2000).

Since there was not a large enough population to explore parent effect on female perceptions of engineering, more research needs to be done to explore this further. Based on the data collected in this research study, it appears that the gender of the mentor did not have an effect on student interest in engineering, but that parent involvement as a mentor may have had an effect. Although small trends emerged within the data, in order to draw conclusions about parent mentor effect on interest or on the gender of the parent mentor, more research with a larger population is needed.

From the interview, the female student explained that mentors on her FIRST robotics team helped her stay motivated and interested in the STEM field. She agreed that STEM mentors bring perspectives and experiences from their careers that help students get a better idea of what that career may be like. Previous research exploring mentors effect on female student perceptions of engineering careers concluded that mentors may play a major role in female students pursuing STEM. Previous research concluded that mentors play an important role in students' self-efficacy, and can shape students' beliefs about their potential success in a particular career setting (Cheryan et al., 2011). Mentors allow students to see themselves as capable enough to pursue a non-traditional career, and increase confidence in their capabilities (Zeldin & Pajares, 2000). Furthermore, mentors may be able to provide learning opportunities and experiences within engineering, which may increase student interest. Women, especially those pursuing a male-dominant career, are responsive to encouragement from mentors (Zeldin & Pajares, 2000).

From this data, STEM mentors of any type and any gender had a large impact on the female student interviewed and had a very positive affect her outlook on pursuing a STEM related career. Although, this was only one student's response and more information would need to be gathered from more students to draw larger conclusions and to further validate the conclusions made by previous mentor research.

Research Limitations

There are a few limitations with the data collected and the conclusions drawn from this research. Claims made in this research are tempered by the reality of a very small sample size. Initially, the hope was that the recruitment process would engage at least 3-4 teams (from varying levels of FIRST) in taking surveys, and at least 4-5 students to interview. After recruitment efforts, only two FIRST teams from the same level of FIRST (both FIRST Robotics Challenge teams) participated in surveys. There were a total of 38 surveys collected from these two teams. In the surveyed population, there were more males than females on the participating teams, and few participating females wanted to be interviewed at season end, or had parent mentors. Since this was a very small population of students to study, the results presented here are not necessarily generalizable. The data collection and small sample size did not allow for clear conclusions to the second research question presented in this study.

When discussing the results of this study, there is a limitation in the comparisons made to previous research. The studies in my literature review referring to engineering were unclear if computer science was included as a part of engineering. Therefore, computer science is referenced separately where applicable. In many of the studies referenced in the literature review, data was collected in different ways or the data was collected over a program unrelated to FIRST. Another limitation to this study is the comparisons connecting previous literature to findings in this study. In many of the studies conducted previously, and referenced in the previous literature, the methodology was very different. For example, in the study conducted by Melchior, Cohen, Cutter, Leavitt, and Manchester (2005), surveys were mailed to prior FIRST participants. None of the participants surveyed were currently in the program. In the study conducted by Burack, Melchior, and Hoover (2018), surveys were mailed to FIRST alumni that were currently in their first year of college/work. Once again, these students were not currently involved in the programs when the surveys were given. Another study referenced in the literature review surveyed students in FLL, FTC and FRC programs. These surveys were distributed at the FIRST events, and filled out individually by team members. Although these surveys targeted student interests, motivation, opportunities, and other similar topics to this study, these surveys were only given once. Therefore, changes in student perceptions were difficult to measure (Witherspoon et al., 2016).

Some studies referenced in the literature review were studies conducted over robotics programs, but were not specifically FIRST programs. One study referenced includes a classroom-based study, where students (pre-K through second grade) were completing an 8-week robotics curriculum using a robotics kit that was not associated with the FIRST program (Sullivan & Bers, 2016). These students were involved in a different type of program that was a requirement for their class, which is much different than being involved in an extracurricular activity. Students were also much younger, which could lead to some discrepancies as well. A second study referenced involved participants in the KISS Institute for Practical Robotics Botball Program. Data for this study was collected via interviews, observations, videotapes, and documentations of blog entries produced by team members (Weinberg et al., 2007). Once again, this study was not a FIRST related program.

The most comparable study referenced in the literature review was the study conducted by Welch and Huffman (2011). The students in this study were from nine different high schools, and all of the students from the FIRST Robotics team at each high school were invited to participate in the study. Although this study is the most comparable, it is unclear how or when the surveys were given to students. Overall, although many of the studies referenced in the literature review had data that was intriguing and helpful for this study, it is unclear whether or not this data is comparable, mostly because each study was conducted in a slightly different way.

From the participants choosing to partake in this study, only one student agreed to participate in interviews. This student did not have a parent mentor involved on their FIRST Robotics team. From the recruitment efforts, the hope was to recruit students to interview who had a FIRST Robotics mentor who was a parent. Although the experiences discussed are valuable, it is only one student’s experiences. Furthermore, because of the low interest in interviews, it is difficult to draw generalized conclusions, although concise conclusions about the small populations of students surveyed may be drawn from the information collected.

Furthermore, another limitation to the data is the idea that there were not any female students had no prior FIRST experience before this FIRST season within the research pool. The initial research plan was to gauge female students' ideas who had not previously been involved in FIRST. By gauging these student ideas, conclusions could have been made about how FIRST may shape students' ideas who have not been involved in a STEM based programs such as FIRST, especially throughout a student's very first season. Unfortunately, initial student ideas could not be measured, because all students had been involved in FIRST for at least one year prior to this FIRST season. Many students did not change their ideas over the course of the FIRST robotics season studied.

Lastly, on the survey presented to students, questions were given regarding both computer science and engineering careers, in hopes of showing students that the two careers were separate. Neither career was defined or described, nor was the difference between the two careers. This may have hindered the students' understanding as to what these careers entailed. A clear description of both careers may have given different results.

For future research, more data needs to be collected to decide whether or not parent mentors may have an effect on female student perceptions of engineering careers. The data collection and small sample size did not allow for clear conclusions to this research question, therefore, further research would need to be conducted to draw conclusions. Secondly, because of the small sample size, more information may need to be collected to confirm any results collected from this study.

REFERENCES

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman. 1-113.

Bandura, A. (2011). Social cognitive theory. In P. A. M. Van Lange, A. W. Kruglanski, & E. T. Higgins (Eds.), *Handbook of social psychological theories* (349-374). Thousand Oaks, CA: Sage Publications, Inc.

Bettinger, E. P., & Long, B. T. (2005). Do faculty serve as role models? The impact of instructor gender on female students. *American Economic Review, 95*(2), 152-157.

Betz, M., & O'Connell, L. (1992). The role of inside and same-sex influencers in the choice of nontraditional occupations. *Sociological Inquiry, 62*(1), 98-106.

Brainard, S. G., & Carlin, L. (1998). A six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education, 87*(4), 369-375.

Brush, S. G. (1991). Women in science and engineering. *American Scientist*, *79*(5), 404-419.

Burack, C., Melchior, A., & Hoover, M. (2018). *Do after-school robotics programs expand the pipeline into STEM majors in college? (RTP)*. Paper presented at the 2018 American Society for Engineering Education Annual Conference & Exposition, Salt Lake City, UT. Paper retrieved from https://www.asee.org/public/conferences/106/papers/22558/view

Carrington, B., Tymms, P., & Merrell, C. (2008). Role models, school improvement and the ‘gender gap’—do men bring out the best in boys and women the best in girls? *British Educational Research Journal*, *34*(3), 315-327.

Cheryan, S., Siy, J. O., Vichayapai, M., Drury, B. J., & Kim, S. (2011). Do female and male role models who embody STEM stereotypes hinder women’s anticipated success in STEM? *Social Psychological and Personality Science*, *2*(6), 656-664.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin*, *143*(1), 1.

DeVries, R. (1997). Piaget's social theory. *Educational Researcher, 26*(2), 4-17.

Dorie, B. L., Jones, T. R., Pollock, M. C., & Cardella, M. (2014). *Parents as critical influence: Insights from five different studies.(RTP).* Paper presented at the 2014 121st ASEE Annual Conference & Exposition, Indianapolis, IN. Paper retrieved from http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1054&context=enegs

Falkenheim, J., Burke, A., Muhlberger, P., & Hale, K. (2017). *Women, minorities, and persons with disabilities in science and engineering* (NSF Special Report No. 17-310). Retrieved March 19, 2018 from https://www.nsf.gov/statistics/2017/nsf17310/static/downloads/nsf17310-digest.pdf

FIRST. (2018, September). Retrieved July 1, 2019, from https://www.firstinspires.org/robotics/ftc

Fisher, T. A., & Stafford, M. E. (1999). Reliability and validity of the Career Influence Inventory: A pilot study. *Journal of Career Assessment*, *7*(2), 187-202.

Fletcher, S., & Haag, S. (2016). *Metrics for efficacy in FIRST robotics programs: Aligning ABET engineering student outcomes with k-12 STEM educational practices.* Paper presented at the 2016 ASEE Annual Conference & Exposition, New Orleans, LA. Paper retrieved from https://pdfs.semanticscholar.org/2fa0/3ba33dfc4b55544f8c55396de3efac92b2a7.pdf?_ga=2.153015993.149406644.1572725146-898341102.1570898966

Geisinger, B. N., & Raman, D. R. (2013). Why they leave: Understanding student attrition from engineering majors. *International Journal of Engineering Education*, *29*(4), 914.

Hackett, G., Betz, N. E., Casas, J. M., & Rocha-Singh, I. A. (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. *Journal of Counseling Psychology*, *39*(4), 527.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics.* Washington, DC: American Association of University Women. 1-134.

Jacobs, J. A. (1995). Gender and academic specialties: Trends among recipients of college degrees during the 1980s. *Sociology Education, 68*(2), 1-98.

Jacobs, J. A. (1996). Gender inequality and higher education. *Annual Review of Sociology, 22*, 153-185. https://doi.org/10.1146/annurev.soc.22.1.153

Kanny, M. A., Sax, L. J., & Riggers-Piehl, T. A. (2014). Investigating forty years of STEM research: How explanations for the gender gap have evolved over time. *Journal of Women and Minorities in Science and Engineering, 20*(2).

Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology, 47*(1), 36.

Lent, R. W., Lopez A. M., Jr, Lopez, F. G., & Sheu, H. B. (2008). Social cognitive career theory and the prediction of interests and choice goals in the computing disciplines. *Journal of Vocational Behavior*, *73*(1), 52-62.

Lindemann, D., Britton, D., & Zundl, E. (2016). "I don't know why they make it so hard here": Institutional factors and undergraduate women's STEM participation. *International Journal of Gender, Science and Technology*, *8*(2), 221-241.

McWhirter, E. H., Hackett, G., & Bandalos, D. L. (1998). A causal model of the educational plans and career expectations of Mexican American high school girls. *Journal of Counseling Psychology*, *45*(2), 166.

Melchior, A., Cohen, F., Cutter, T., Leavitt, T., & Manchester, N. H. (2005). *More than robots: An evaluation of the first robotics competition participant and institutional impacts.* Manchester, NH: FIRST.

Quimby, J. L., & Santis, A. M. (2006). The influence of role models on women's career choices. *The Career Development Quarterly*, *54*(4), 297-306.

Sax, L. J. (2008). *The gender gap in college: Maximizing the developmental potential of women and men.* San Francisco, CA: Jossey-Bass.

Sonnert, G. (2009). Parents who influence their children to become scientists: Effects of gender and parental education. *Social Studies of Science*, *39*(6), 927-941.

Sullivan, A., & Bers, M. U. (2016). Girls, boys, and bots: Gender differences in young children's performance on robotics and programming tasks. *Journal of Information Technology Education: Innovations in Practice*, *15*, 145-165.

Swan, A. (2015). Experiential and contextual factors that shape engineering interest and educational decision-making processes among female students. *NASPA Journal About Women in Higher Education*, *8*(1), 82-100.

Tang, M., Fouad, N. A., & Smith, P. L. (1999). Asian Americans' career choices: A path model to examine factors influencing their career choices. *Journal of Vocational Behavior*, *54*(1), 142-157

Tarampi, M. R., Heydari, N., & Hegarty, M. (2016). A tale of two types of perspective taking: Sex differences in spatial ability. *Psychological Science*, *27*(11), 1507-1516.

Weinberg, J. B., Pettibone, J. C., Thomas, S. L., Stephen, M. L., & Stein, C. (2007). *The impact of robot projects on girls' attitudes toward science and engineering.* Paper presented at the 2007 RSS Workshop on Research in Robots for Education, Atlanta, GA.

Welch, A., & Huffman, D. (2011). The effect of robotics competitions on high school students' attitudes toward science. *School Science and Mathematics*, *111*(8), 416-424.

Witherspoon, E. B., Schunn, C. D., Higashi, R. M., & Baehr, E. C. (2016). Gender, interest, and prior experience shape opportunities to learn programming in robotics competitions. *International Journal of STEM Education*, *3*(1), 18.

Women in Computer Science. (2019). The current state of women in computer science. Retrieved June 29, 2019, from https://www.computerscience.org/resources/women-in-computer-science/

Zeldin, A. L., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research Journal*, *37*(1), 215-246.

APPENDIX A

IRB APPROVAL

IRB 19-0008 - Study Approval
1 message

Anita M Gordon <anita.gordon@uni.edu> Fri, Aug 10, 2018 at 12:51 PM
To: olsonkaq@uni.edu
Cc: jeff.morgan@uni.edu

Dear Investigator(s):

Your study, Impact of Mentoring and Participation in FIRST Robotics on Middle and High School Age Female Perceptions of Engineering Careers, has been approved by the UNI IRB, effective 8/10/18. You may begin recruitment, data collection, and/or analysis for your project. You are required to adhere to the procedures and study materials approved during this review, as well as to follow all IRB policies and procedures for human subjects research posted on the IRB website at rsp/uni.edu/IRB-home.

Your study has been approved in the following category: Expedited 6.

Approval for your study will **expire one year** from your approval date above. Beyond that date, you may not recruit participants, or collect and/or analyze data without continuing approval. To renew approval for your project, submit the Continuing Review and Closure form before the expiration date The IRB office will email you the form 4-6 weeks prior to expiration or you can download it from the IRB website. **When your study ends,** you must download and submit the Continuing Review and Closure form as a **brief final report on your project**. If you are a student and planning to leave campus at the end of the academic year, make sure to submit this before you leave.

If you need to make any changes to your study, you must request approval of the changes before continuing with the research. Requests for modifications should be emailed to the IRB Administrator at anita.gordon@uni.edu.

If during the study you observe any problems or events pertaining to participation in your study that are *serious* and *unexpected* (e.g., you did not include them in your IRB materials as a potential risk), you must report this to the IRB **within 10 days.** Examples include unexpected injury or emotional stress, missteps in the consent documentation, or breaches of confidentiality.

If you need a signed approval letter, contact the IRB office and one will be provided for your records.

Best wishes for your project success.

Anita Gordon
IRB Administrator

--

Anita M. Gordon, PhD
IRB Administrator
Director of Research Ethics
Office of Research & Sponsored Programs
University of Northern Iowa
213 East Bartlett
Cedar Falls, IA 50614-0394
319-273-6148

APPENDIX B

COACH RECRUITMENT SCRIPT

FIRST Program coaches,

My name is Kirsten Olson, and I am working towards a Master's degree in Science Education at the University of Northern Iowa. I am a physics/chemistry teacher and currently coach a FTC team in the Cedar Falls Community School District. Through observation in the last year, I became interested in how mentoring on a FIRST team may impact student perceptions of engineering careers. My interest in FIRST and mentoring helped me choose my Master's thesis project, titled *The Impact of Mentoring and Participation in FIRST Robotics on Female Perceptions of Engineering Careers.* This study is designed to explore the effect of mentors on middle and high school age students participating in a FIRST Program, and how those mentors might shape student perceptions of engineering careers. Any female middle and high school aged students (11-18+) will be able to participate in the study if they are involved in a FIRST Program.

I am inquiring about coach interest in gaining evaluation data from their FIRST Robotics participants. If you decide that you would like to help collect information for this study, you will disseminate pre-season (takes 15-20 minutes) and post-season (takes 15-25 minutes) surveys to all students on your FIRST Robotics team. Both surveys are generic FIRST surveys that will also help you to inform the upcoming season and explore what types of interests your FIRST students may have. All survey answers (both pre and post-season) will be available for coaches to read, but will remain confidential. The pre-season survey will be administered at the second or third practice of the season, dependent on your schedule and when would work best for you. The post-season survey will be administered at the end of the FIRST season. The day in which the post-survey is administered will be team dependent, since each team finishes the season at a different time. The survey can be given in the FIRST Program practice environment, or where ever the team regularly meets.

Although all students are taking the survey for evaluation purposes, female students will be given the option to participate in my research project by having their survey data analyzed further. Female students that agree to have their answers further analyzed for research will consent to do so.

Any coach that agrees to administer surveys to students on their team will be compensated with a $15 Amazon gift card, and will have the ability to view confidential student surveys that will help them inform their upcoming season. Coaches will also be able to analyze confidential post-season surveys, to help them better prepare for the next FIRST season. If you choose to administer surveys to your team, female students will have the ability to choose whether or not they would like to have their answers further analyzed for research purposes.

If you have questions or are interested helping to collect information for the study, please contact me, Kirsten Olson at ph: 641-220-3405 or email: olsonkaq@uni.edu . Thank you for your consideration!

APPENDIX C

LETTER OF COOPERATION

The ______________________ is pleased to collaborate with Kirsten Olson on the
(institution/organization name)
project *Impact of Mentoring and Participation in FIRST Robotics on Student Perceptions of Engineering Careers*.

We understand that participating in this research will include pre-season and post-season surveys, along with a select number of students that may choose to participate in interviews about their experiences in their FIRST Program. We had ample opportunities to discuss the research with the principal investigator and to ask for clarification. Furthermore, the principal investigator for this project will maintain confidentiality of all research participants in all phases of this project. According to our agreement, project activities will be carried out as described in the research plan reviewed and approved by the University of Northern Iowa Institutional Review Board.

We look forward to participating in this project, and please consider this communication as our Letter of Cooperation.

Sincerely,

______________________________ ______________________________
(Printed Name of Representative) (Signature of Representative)

____
(Title of Representative)

APPENDIX D

COACH NARRATIVE

Coaches: Please read the following narrative to students on your FIRST Program team.

FIRST Program students,

The survey that you are about to take is a generic FIRST pre-season survey that all students will participate in. This will help inform the coaches about what kinds of things you are interested in for the upcoming season. This survey will be confidential to coaches, which means that the coaches will know what students have participated but not what they have answered. The survey will take approximately 15-20 minutes to complete. This survey will ask about previous FIRST experience, interest in FIRST, and interest in engineering/computer science careers.

There will also be a FIRST post-season survey that will be administered by your coach at the end of the season, and will take approximately 15-25 minutes. The day in which this survey will be administered is team dependent, as each team finishes the season at a different time. This survey will give coaches ideas about what types of things you enjoyed throughout the season. The post-season survey will ask the same questions about engineering/computer science related careers, along with some questions about mentors on their team, future career interests, and experiences throughout the FIRST season.

This survey is also being used to conduct research on female student attitudes. Female students, you have been invited to participate in a research project conducted through the University of Northern Iowa. The following information is provided to help you made an informed decision whether or not to participate. If you choose to participate, your survey results will be analyzed further and used in the research project. The research project plans to explore students experiences with mentors within FIRST and feelings about engineering/computer science related careers.

All female students will be given permission forms with more information to take home and read over with your parents. This research will require that you get permission to participate. If you are over 18, you only need to consent. If you are under 18, you will need to consent and get your parents permission. All female students will be given parental permission and consent forms that need to be returned whether you do or do not want to participate in the study. If you do not want your survey answers to be analyzed, you will simply check the “no” box at the end of the consent form. If you do want to participate in the study, you will check the “yes” box before signing the forms. These forms also have information about who to contact if you have more questions. Whether you decide to participate in the research or not, these forms will need to be returned.

APPENDIX E

PRE-SEASON QUESTIONAIRE

Student Pseudonym: ________________________________

(*day of your birthday*) - (*number of siblings*) - (*birthday month name*) - (*favorite color*)

Examples: 31-0-October-Purple 19-2-April-Red

FIRST Pre-Season Questionnaire

1. Circle your gender. Male Female Other Prefer not to say

2. What FIRST Program are you participating in for the 2018-2019 FIRST Season?

3. How many years have you participated in any FIRST Program?

4. Did a family member serve as a mentor on your any of your FIRST team(s) in the past? If this is your first year on a FIRST team, does a family member plan to serve as a mentor?

    a. If yes, when and who?

5. What careers are you most interested in?

6. What reason(s) did you choose to participate in a FIRST Program this year?

7. What do you hope to gain from participating in FIRST this year?

INSTRUCTIONS: Please read each sentence. Mark the statement that best describes your opinion now.					
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I am interested in engineering.	SD	D	U	A	SA
I am confident that I could be an engineer.	SD	D	U	A	SA
I am interested in computer science.	SD	D	U	A	SA
I am confident that I could be a computer scientist.	SD	D	U	A	SA
I am interested in a career that involves engineering.	SD	D	U	A	SA
I am interested in a career that involves computer science.	SD	D	U	A	SA
I am confident that I could do a career involving engineering.	SD	D	U	A	SA
I am confident that I could do a career involving computer science.	SD	D	U	A	SA

APPENDIX F

UNIVERSITY OF NORTHERN IOWA
HUMAN PARTICIPANTS REVIEW
SURVEY - INFORMED CONSENT/ASSENT

Project Title: *Impact of Mentoring and Participation in FIRST Robotics on Middle and High School Age Female Perceptions of Engineering Careers*

Name of Investigator: Kirsten Olson

Invitation to Participate: You have been invited to participate in a research project conducted through the University of Northern Iowa. The University requires that you give your signed agreement to have your survey data analyzed for this project. The following information is provided to help you make an informed decision whether or not to participate.

Nature and Purpose: This study is designed to explore the effect of mentors on middle and high school age females participating in a FIRST Program, and how those mentors might shape female student perceptions of engineering careers. This study hopes to investigate the relationship between involvement in FIRST Programs, mentors within those programs, and how those two variables might affect female students beliefs that they could be successful in an engineering career.

Explanation of Procedures: Generic FIRST pre-season surveys have been administered to you by your FIRST program coach. Pre-season surveys have been given before the season starts, and the post-season surveys will be given once the season has ended. These surveys are generic surveys that ask about interest in engineering/computer science careers and interests in FIRST. All students provided a pseudonym code instead of their names to keep surveys confidential. Coaches will be given the answers to these surveys, to help them better plan a FIRST season tailored to your interests.

All female students are given the option to have their answers analyzed further for research purposes. If you agree, the data and information will be presented as a Master's Thesis project at the end of the study. All names will be replaced with pseudonyms if mentioned within the study, to keep your information confidential.

If a student is found to be at all connected to the principal investigator in any way (ex: prior student, family member, etc.) the participant's participation in the study may end, without regard to the participant's consent.

Discomfort and Risks: Risks to participation are minimal. Risks to participation are similar to those experienced in day-to-day life, such as inconvenience and time. There are no foreseeable risks to participation.

Benefits and Compensation: There would be no direct benefits that may result from this study. As compensation for time and inconvenience, female students who choose to have their survey data analyzed for research purposes will be entered into a lottery for three $15 Amazon gift cards. Compensation is distinct from benefit, but would compensate participants for time given up to read research information and make an informed decision as to whether or not to have their data used. If a female student decides to have their data analyzed in the pre-season survey, but decides to voluntarily or involuntarily withdraw before the post-season survey, the participant's name will be entered into the drawing one time. If the female participant decides to have their data analyzed for both the pre-season and post-season survey, the participant's name will be entered into the drawing twice. This way, if a participant plans to withdraw their name halfway through the season, they may still have a chance to win a gift card and be compensated for their time spent on the first survey.

Confidentiality: Information obtained during this study which could identify the participant will be kept strictly confidential. The summarized findings with no identifying information will be used as a Master's Thesis project, and may be published in an academic journal or presented at a scholarly conference. Participants will be asked to write pseudonyms on questionnaires and assent forms for data tracking purposes only, and will remain confidential.

The principal investigator is a mandatory reporter, meaning that the principal investigator is required to report suspected cases of child abuse or neglect to government authorities. This means that if suspected child abuse or neglect comes up in a survey, the case will have to be reported. If something comes up and it is reported, the details of the research or specific student answers will not be included in the report. The only details included in the report will be relevant to the disclosure of the behavior being reported.

Right to Refuse or Withdraw: Participation is completely voluntary. The participant is free to withdraw from participation at any time or to choose not to participate at all, and by doing so, the participant will not be penalized or lose benefits to which he/she is otherwise entitled in the FIRST Program.

Questions: If you have questions about the study you may contact or desire information in the future regarding your child's participation or the study generally, you can contact Kirsten Olson at ph: 641-220-3405 or email: olsonkaq@uni.edu . You can also contact the project investigator's faculty advisor Jeffrey Morgan at the Department of Physics and Science Education, University of Northern Iowa ph: 319-273-2290 or the office of the Human Participants Coordinator, University of Northern Iowa, at ph: 319-273-6148, for answers to questions about rights of research participants and the participant review process.

Agreement:

❑Yes, I would like to participate in this study. I am under 18 years of age and will return a parental permission form to participate in this study.

❑Yes, I would like to participate in this study. I am 18 years of age or older. I am fully aware of the nature and extent of my participation in this project as stated above and the possible risks arising from it. I hereby agree to participate in this project. I acknowledge that I have received a copy of this consent statement.

❑No, I would not like to participate in this study.

Student Pseudonym: ____
(*day of your birthday*) - (*number of siblings*) - (*birthday month name*) - (*favorite color*)
Examples: 31-0-October-Purple 19-2-April-Red

_________________________________ _____________________
(Signature of participant) (Date)

_________________________________ _____________________
(Printed name of participant) (Participant email)

_________________________________ _____________________
(Signature of investigator) (Date)

_________________________________ _____________________
(Signature of instructor/advisor) (Date)

APPENDIX G

POST-SEASON QUESTIONAIRE

Student Pseudonym: ___________________________________
(day of your birthday) - *(number of siblings)* - *(birthday month name)* - *(favorite color)*
Examples: 31-0-October-Purple 19-2-April-Red

FIRST Post-Season Questionnaire

1. Circle your gender. Male Female Other Prefer not to say

2. What FIRST Program did you participate in for the 2018-2019 FIRST Season?

3. How many years have you participated in a FIRST Program (including this one)?

4. Did a family member serve as a mentor on your FIRST team this season? Did a family member serve as a mentor in your FIRST team(s) in the past?

   a. If yes, who and when?

   b. If yes, describe a favorite experience or experiences that you had with your family mentor this season or in past seasons.

Please answer the following short answer questions to the best of your ability.

What careers are you most interested in?

Describe your experiences in FIRST this season: What did you like about FIRST?

What were you most excited about doing this FIRST season? What were you least excited about doing?

Describe your favorite experience or memory from this FIRST Program season.

What are some words or phrases that you think of when you hear the word "engineer" ?

Are you interested in becoming an engineer someday? Why or why not?

If you are interested in becoming an engineer someday, what are some things that helped you become interested?

If you are not interested in engineering, what experiences made you uninterested in an engineering career?

INSTRUCTIONS: Please read each sentence. Mark the statement that best describes your opinion after the 2018-2019 FIRST Season.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
I am interested in engineering.	SD	D	U	A	SA
I am confident that I could be an engineer.	SD	D	U	A	SA
I am interested in computer science.	SD	D	U	A	SA
I am confident that I could be a computer scientist.	SD	D	U	A	SA
I am interested in a career that involves engineering.	SD	D	U	A	SA
I am interested in a career that involves computer science.	SD	D	U	A	SA

I am confident that I could do a career involving engineering.	SD	D	U	A	SA
I am more confident that I could do a career involving computer science.	SD	D	U	A	SA
Female Students Only: Would you be interested in participating in an interview about your experiences during your FIRST season?	Yes	No	Not sure, but would like more information		

APPENDIX H

SEMI-STRUCTURED INTERVIEW QUESTIONS

Interview questions will be personalized based on student survey answers,. The following questions will be asked of each participant, though follow up questions to gather more detail or a more complete understanding of the student's answers on the questionnaire or responses to these questions may be asked.

1. On the post-season survey, you were asked about words or phrases that come to mind when you think of an engineer. You answered with (remind them of what they listed). Can you explain what experiences you have had that might have caused you to think of these words/phrases?

2. The following question will be dependant on the student's survey answers:

   If yes: You indicated on the survey that you may be interested in becoming an engineer someday. What are some things that helped you become interested?

   If no: You indicated on the survey that you believe you aren't interested in an engineering career. What experiences made you uninterested in an engineering career?

3. Do you believe that you could be successful as an engineer? Why do you believe that?

4. What types of skills did you acquire or develop over the FIRST Robotics season? What are some experiences that helped you acquire those skills?

   Do you believe that any of these skills would be helpful in a career in engineering? Why do you believe that?

5. Describe your experiences with a family member acting as a mentor on your FIRST Robotics team.

   Did you enjoy it? Was it helpful? What experiences did you have with your family member throughout this season that you enjoyed?

APPENDIX I

STUDENT INTERVIEW TRANSCRIPT

RESEARCHER: OK so I just have kind of a list of like eleven questions.If we go off the beaten path it's totally fine. So I start talking about some or if some comes to mind that you want to talk about feel free. This isn't anything that we have to specifically stick to. But I guess my first one is just take a moment to tell me about yourself and your experiences because I know you said you're involved in first for three years right. So just take a minute talk about that talk about your experience what you like what you dislike whatever whatever comes to mind.

STUDENT: So I started doing first in middle school my eighth grade year I knew about it my seventh grade year but I didn't think about it that much. And so my friends convinced me to go out eighth grade and I ended up having a really fun time building the little Lego robots and just enjoying being with the team. And then I went to the open house for FTC and FRC and I was going to do both of them until I realized how much of a time commitment to both there would be and I decided it would be best to start with a FRC. And I'm really glad I did because I really enjoy the team and it's become like a it's really like a family on the team. And so we're a very small team and it's definitely brought me more out of my shell because I wasn't very like outgoing to talk to people. But being in robotics and drive team you have to be willing to talk to anyone that comes up to you. And so it's just a really fun experience to push the limits of it and to be comfortable.

RESEARCHER: Awesome. So one year in FLL and then two in FRC?

STUDENT: Yeah.

RESEARCHER: Perfect. Secondly what types of skills did you acquire or develop over the first robotics season so just this last season that you participated in.

STUDENT: I think I really got my communication skills up and my leadership and towards the end of the season we pick you team captains. And so I got elected as one. So it's really kind of pushed me to step up a bit more.

RESEARCHER: Yeah. What all does the team captain do for the team?

STUDENT: So we kind of have to take charge of the things our team is a student led mentor guided so OK the ones who have to run the meetings and keep people on track and make sure all the dates are set and stuff like that.
RESEARCHER: Awesome. What are some experiences that helped you acquire some of those communication and leadership skills?

STUDENT: Definitely being at the competitions and being thrown into. Any kind of circumstance you could think of and having to think on the spot because it's timed and everything like that it really just puts you right out there to go for it.

RESEARCHER: So were you part of some presentations during competitions? I know that FRC does big presentations sometimes at some of their competitions.

STUDENT: Our team does chairmans but I didn't help with that because of being on Drive team it conflicts too much.

RESEARCHER: Right, right. Ok. So the communication and leadership skills that you talked about- do you think these skills would be helpful in a career in engineering?

STUDENT: I do think that I've also been doing programming on the team and so that's something that also got me into it. And so I'm getting a lot of communication and being able to sometimes help people who don't know the programming language either and building the bridges so they can also understand that something.

RESEARCHER: Yes definitely. OK. One thing that you mentioned on your pre-season survey that you hope to gain were communication skills which you talked about. That's really good. And the other thing you talked about was gaining some software skills so can you describe how first helped you develop those skills throughout the season. And you talked a little bit about programming.

STUDENT: At the beginning I wasn't the greatest with the shop and like the tools and knowing what to do. But throughout especially this year since we had so few members you had to be flexible with everything. And so I learned a lot more about the hands on aspect of building and just learning every aspect of the team.

RESEARCHER: So you kind of talked about that, so discuss the experiences that helped you develop those skills.

STUDENT: Kind of working in the shop more than anything else besides that other than just this You're having to really step up with the other two captains and try to take control of everything and keep things going smooth.

RESEARCHER: Definitely definitely. Another thing you spoke about on your survey was team bonding and I know you talked about that a little bit already in team building. So describe some of your favorite team bonding experiences through FIRST.

STUDENT: My freshman year we did a group trip to rafting and that was one of our first big team bonding that year and there was a lot of fun and it really got us to work together. And right now we're thinking about doing another one coming up either escape room for all of us to think through or for us to do some kind of kickball but there's also just a lot of team bonding when we had this past weekend we took us three captains to Washington D.C. for NEC and that was a whole week together going through talking to senators and things like that. So it really brought us together a good one.

RESEARCHER: So this program that you went to is it something through FIRST or what is..

STUDENT: Yeah. So it's a national advocacy conference. And so the main goal was to talk to the senators and representatives of our state and get them to help support first through. ESA and make sure that the helping fund it and telling them from a student's perspective how important it is to us that they help with it. And then we also talked about a Coin Act that was going through that the House had already put through. So we talked to the Senate about that.

RESEARCHER: Awesome. That was really cool. So do you think so this team bonding all this stuff that you've done with the national advocacy conference all this teamwork stuff that you've been doing. How do you think that team bonding helps or doesn't help students gain interest in first or STEM based careers.

STUDENT: I think it really helps especially if you start doing them when a bunch of new students come onto the team so that they can get comfortable with everyone. It's not as pressured as like going straight into the shop and maybe you don't know what you're doing. It's just. Hanging out getting to know everyone and making some new friends.

RESEARCHER: On your postseason survey you were asked about words or phrases that come to mind when you think of an engineer. The two words that you answered with were creativity and innovation. Can you explain what experiences you have had that might have caused you to think of these words or phrases?

STUDENT: When we're out in the shop and were starting to build the robot. And sometimes we come across some very interesting problems that you really have to just think out of the box because everything else you try doesn't work. And just having that open mind and not being closed minded and just having to try things and nothing's really a dumb answer because sometimes one of the most outgoing things can work the best.

RESEARCHER: Definitely, awesome. Onto question number six, here. Do you believe that you could be successful as an engineer and if so, why do you believe you could be?

STUDENT: I think I could. I think that going through first has prepared me with a lot and I still have two more years to go. I can definitely learn a lot more. I think that if I wanted to continue to pursue software as well, I could definitely keep expanding my mind and get into a good job with that. A lot of the seniors that graduate end up helping at like John Deere and becoming into that and they've almost all gone into some type of engineering career.

RESEARCHER: Awesome. Very cool. So that being said I know you're talking about software a little bit. Have you considered computer science at all?

STUDENT: I've thought about it. My freshman year it was completely new to me because it went from block programming to hey this is writing code. Yeah. And I got freaked out but I started learning it and then this past year for sophomore year I kept doing it with a new upcoming freshman and I kind of steered away from it a bit and helped out in the shop. And then this year I'm actually learning cad. So I'm kind of trying everything.

RESEARCHER: Yeah yeah for sure. Well I can kind of relate to that experience. I coach FTC and my first year coaching FTC. I knew nothing. I knew nothing about first and nothing about robotics I knew nothing about programming. And I remember some of the kids like asking some things and I'm just like I have no idea. So it's a lot. But you're right once you get into it you know some of that coding gets a little bit easier and it's not quite scary it's just kind of like learning a new language.

RESEARCHER: Let's see you indicated on your survey so and you kind of answered this with your last question. You definitely indicated that you are kind of interested in engineering and one of the reasons you said was you love the creativity with becoming an engineer and there are so many different career options. So what are some things that helped you become interested.

STUDENT: I'm just going through each year and seeing all the different things they can do, like OK this is programming, that's CAD, and then you can kind of look into more engineering jobs and if there's something you want to do there is definitely a good job out there that can relate to it. It is just almost unlimited.

RESEARCHER: Yeah definitely. There are so many and I think some people don't even realize how many facets there are of engineering there's just so many. Number eight you mentioned that first has helped you become more and more interested in becoming an engineer. Explain how first played a role on your engineering interests.

STUDENT: Just opening my mind to everything that I wouldn't have tried if I wasn't in it. I definitely wouldn't have looked at programming and I might have looked into CAD but everything just kind of seemed like, right. But now that I was in it and I kind of had to find something to do and start learning everything, I do actually enjoy this and it's something I could see myself doing

RESEARCHER: So when you originally joined FFL you said a friend kind of talked to you. Is that why you said so before that and did you have any interest in engineering at all.

STUDENT: I mean I kind of did it it wasn't something I think especially in middle school I thought engineering I didn't really think about everything that came with it. I kind of thought like maybe just like mechanical. And that was kind of me. And I never really sparked my interest in school always kind of talked about it but it wasn't really out there because the school doesn't really fund us. And so since it wasn't always just like posted everywhere. So I was like oh you should do a bodyguard and a lot of people say what about us. I think I like battle bots and some like that. I used to watch that. So that was the first thing that came to my mind and I was like oh this could be kind of cool. And then I joined it and it wasn't that a lot but no. So a lot of fun. And even just being on a team with people and it was really cool.

RESEARCHER: Awesome. So you indicated on your survey that you don't have a parent that serves as a mentor on your first robotics team. Correct. OK. Although your parents haven't served on your robotics team as mentors at all how have your parents contributed to your interest in engineering or STEM related fields.

STUDENT: Both my parents have been really supportive and helping me get to all the different events and making sure that I'm able to get everything done I need to get done for robotics and making sure that there's somewhere I need to be there when I have to be there and they definitely help with different fundraisers and they are very supportive when we do pizza ranches and stuff like that. They come out and help and try to help spread the word with social media.

RESEARCHER: Awesome. So are your parents involved in a STEM related career at all?

STUDENT: No.

RESEARCHER: OK just curious how do I know you said that your team is student led and mentor. Kind of helped. Right. So how many mentors do you have in your first robotics team?

STUDENT: We have five.

RESEARCHER: Five. OK. Awesome. How many are male and female? And what types of careers to these mentors have?

STUDENT: We have two female and three male. So three of them work at John Deere and so they also volunteer their time to help us. One of them was a teacher and was at our elementary and got into it with her daughter. And then the other one her daughter was in FRC and now that she's graduated she's still stuck around to help the team stay with us.

RESEARCHER: Describe your experience with some of these mentors on your first team.

STUDENT: So our mentors are very just they kind of helped make the team feel just like a family. It's definitely I would consider like my team and my robotics group like my safe place to go. I definitely feel comfortable if I have something going on to talk to them and it's very just welcoming and they never put you down always trying to help encourage you. They were very strict staying with the whole student led mentor guided and kind of putting you out there to get you to think.

RESEARCHER: Do you think that having these mentors on your first robotics team is helpful or not helpful to students interested in engineering or STEM related careers?

STUDENT: I definitely definitely think that they're helpful especially the mentors that I say I like working at deere you are doing something in that field they can kind of bring their own personal insight to it and maybe show it in a way that maybe others wouldn't be able to and definitely get the students to open their minds and really think about things.

RESEARCHER: The three mentors that work at John Deere Are they male female.

STUDENT: The three that work at John Deere are male.

RESEARCHER: Arm and last but not least are there any other. Is there any other information or any other experiences you'd like to share with me today.

STUDENT: Mainly just it's just a really fun thing they get into and I kind of do wish I got into it like my seventh grade year and just started getting into even more. We also just started. A fellow junior team. At elementary and this last year was our first year and I was one of the three students who decided to help mentor. And so that was a really cool experience to see is just even like elementary kids that they really know a lot. And to see their minds like work in such a way to solve a common problem and work together and it's really it's really cool to see cool.

RESEARCHER: How have the elementary kids responded to you. Like have they been pretty receptive.

STUDENT: They ended up really enjoying it and they actually came down to one of our competitions and came to support us and they were really excited to see like the big robot and compared to the you know the little ones and the very amazing and I know they all really loved it and wanted to do it again. And it's really cool to. Even make the connections with the little kids because you know soon they're gonna be the high school kids doing this and taking on you know we leave behind and. It's just the different connections you make with them. It's really eye opening.

RESEARCHER: Cool awesome. That's really cool to hear. Well that's all I have. Do you have anything else that you would like to say or talk about?

STUDENT: I think that’s about it.