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Attracting Secondary Students to STEM Using a Summer Engineering Camp

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ATTRACTING SECONDARY STUDENTS TO STEM
USING A SUMMER ENGINEERING CAMP

by
Murad Mahmoud

A dissertation submitted in partial fulfillment
of the requirements for the degree
of

DOCTOR OF PHILOSOPHY
in
Engineering Education

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Abstract

Attracting Secondary Students to STEM Using a Summer Engineering Camp

by

Murad Mahmoud, Doctor of Philosophy

Utah State University, 2018

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Department: Engineering Education

The purpose of this research was to investigate the effect of a summer engineering camp on the level of interest of middle school students’ in Science, Technology, Engineering and Mathematics (STEM) fields as well as the factors influencing their interest. The research also discusses their parents’ perceptions of STEM. Students attended an outreach summer engineering camp, designed to increase the interest and motivation of middle school students to go into STEM fields, specifically engineering. This camp is part of a seven-year grant funded by the Department of Education as part of the GEAR UP program. The grant’s overall goal is to help more than 3,000 middle and high school students’ improve their academic achievement, creating a pipeline of academically prepared students enrolling, and excelling in college. The engineering summer camp targets 6 to 12th grade underrepresented students and science teachers. The engineering camp discussed here is one component of the GEAR UP grant.

Participating students (N=33) and teachers spent a week performing real engineering research investigation in collaboration with engineering research faculty at a land grant university to study the interaction of urban and natural areas and their effect on
water quality in a local water shed. During the summer camp, teacher and student participants developed engineering research hypotheses, tested those hypotheses, and thought like engineers. The summer camp culminated in research posters and slide (PowerPoint) presentations, where teams of students led by a science teacher, described the research findings of their week-long camp. The teams discussed an engineering research hypothesis, and a simple experiment to follow, to verify that hypothesis, helping them think like engineers.

Participating students completed surveys at the beginning, and at the end of the summer camp. Those surveys included quantitative and qualitative open-ended questions about their interest in STEM, their engagement with STEM, and their friends’ perception of science. Similarly, the parents of participating students, completed surveys about their education, income, and perception of science, math and engineering. While the parents did not attend the camp, they were involved via a blog created to keep the parents updated about the camp activities, and get them involved. The blog was updated daily, with a short description of the activities of the day, photos/video of the day, as well as a link to all the photos/videos taken that day. The blog also contained quotes from the students’ daily journals. Data from both students and parents, was analyzed and correlated to find the factors influencing the students’ interest.

Results showed a positive trend STEM interest for both students and parents. The students’ interest in STEM fields increased, particularly for those students who started the camp with low interest, and for female students who experienced bigger gains than their male counterparts did. The parents’ perception of STEM also improved after their children attended the camp. Factors influencing the students’ interest in STEM fields
included their abilities in STEM related fields, the grades they achieve in their science and math courses, how much they enjoy STEM related activities, their level of STEM engagement, the perception of their friends towards STEM fields, and the perception of their parents regarding science and engineering. Both quantitative and qualitative data showed very similar trends.
The purpose of this research was to study the benefits of having middle school students attend a summer camp focused on the fields of Science, Technology, Engineering and Mathematics (STEM). A lot of research funding is being used in such camps to help get more students into STEM fields as there is a lack of graduates in those fields. Therefore, it is important to understand the benefits and effectiveness of such camps.

Students, teachers and parents were involved in this research. Students and teachers attended a one-week engineering camp at Utah State University while parents were involved via a blog updated daily with a summary of the activities of the day, pictures, and quotes from the students.

The results show that those kinds of camps are effective at increasing students’ interest in STEM fields and in improving parents’ perceptions about those fields. Interestingly, students who started the camp with low interest in STEM fields gained a lot more from the camp than the other students. Similarly, female students also gained a lot more through the camp than male students. This leads us to believe that future camps should target students that stand to gain more from such camps.
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Murad Mahmoud
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Chapter I

Introduction

Science, Technology, Engineering and Mathematics (STEM) disciplines are essential to society, and to competing in the global economy. Today, the role of STEM education, not only provides students with STEM content knowledge and understanding, but also prepares them to be interested in, and committed to pursuing careers in the STEM workforce. According to the President’s Council of Advisors on Science and Technology, “We must prepare all students, including girls and minorities, who are underrepresented in these fields, to be proficient in STEM subjects. And we must inspire all students to learn STEM and, in the process, motivate many of them to pursue STEM careers” (PCAST, 2010) (p. 11). According to the U.S. Department of Commerce, Economics and Statistics Administration, STEM workers drive the nation’s innovation and competitiveness by creating new ideas, companies and industries. However, many U.S. businesses have concerns about the availability of STEM graduates (Langdon, McKittrick, Beede, Khan, & Doms, 2011). The need for vast expertise in STEM fields is vital to maintaining the United States’ security and global economic competitiveness. The focus is to find possible solutions that will help the nation overcome this problem. (Business High Education Forum: The U.S. STEM Undergraduate Model, 2013)

In addition to an unfilled need in STEM fields, there is a lack of interest for students in the United States to go into STEM fields, particularly engineering (Kazmierczak, 2005 and Callahan & Callahan, 2004). According to the Business and Higher Education Forum (2010), only about 8.6% of high school students choose to go into STEM fields every year. As Figure 1 shows, the STEM education pipeline narrows
very quickly. In 1997, there were 3.8 million 9th graders in the United States. In 2001, 2.7 million of those 9th graders graduated from high school. However, by 2007, only about 233,000 of those 9th graders had earned a STEM bachelor’s degree (Business High Education Forum, 2010). Out of those, only 68,274 engineering bachelor’s degrees were awarded, or 2.5% of the total number of high school graduates (National Science Foundation, 2016).

Figure 1. The U.S. STEM Education Pipeline (U.S. STEM Education & Modeling project, Business High Education Forum, 2010)

In addition to a lack of interest, STEM education is facing a diversity issue. Some ethnic groups, and women, are underrepresented, especially in engineering. Women make up half of the population, but many are not interested in going into engineering for various reasons, including not feeling welcome in the engineering environment, not encouraged or expected to succeed in that field (Lambright, Johnson, & Coates, 2009), or
the misconception that engineering is a ‘nerdy’ career (Borrego & Bernhard, 2011). According to Johnson, Ozogul, DiDonato & Reisslein (2013), females generally display much less interest going into STEM fields, and females represent only 20% of all engineering students (The National Science Board, 2016).

Moreover, the number of engineering graduates in the United States is currently lagging behind other major competitors in the global economy, such as China and India. The United States contributes around 4% of the total engineering graduates worldwide, compared to 34% for China, and 17% for Europe (National Science Board, 2012). Similarly, the percentage of STEM graduates in the United States is far behind other major economic powers in the world, including China, Japan and Germany. According to the U.S. Congress Joint Economic Committee, the United States ranked 27th out of 35 countries that are members of the Organization for Economic Co-operation and Development (OECD), in terms of the percentage of STEM graduates to total graduates per year (U.S. Congress Joint Economic Committee, 2012). The head of the Indicators and Analysis Division of the OECD indicated that only the countries with STEM-literate populations would be competitive in the international economy, and that America's lead in student achievement is slipping, as other countries take education reform to heart (Schleicher, 2007).

Meanwhile, between 2000 and 2010, the growth in the STEM job market was three times that of non-STEM fields according to the Economics and Statistics Administration, and STEM jobs in the U.S. are projected to grow by 17% between 2008 and 2018, compared to 9.8% of non-STEM fields during the same period (Langdon et al., 2011).
There are steps that could be taken to build interest in STEM fields, and produce more STEM graduates. Laut, Bartolini & Porfiri (2015) believe that STEM recruitment is critical for the economy and society, and the results of their research show that students who participated in their outreach program have more interest in going into STEM fields. One national study indicated that most college students who majored in a STEM subject had intentions to do so while still in high school (Adelman, 1998). This suggests that, in order to enhance the representation of women and minorities in STEM careers, it is important that they be exposed to interventions in middle and high school.

Outreach programs targeted at schools is one of the methods often used to build interest in STEM, and findings suggest that outreach programs are effective, especially on elementary school students (Johnson et al., 2013). Summer outreach programs, where students learn about engineering outside the school environment, have been largely successful in increasing student interest in STEM fields (Abaid, Kopman and Porfiri, 2013; Babb, Saar, Friesen & Brandon, 2014; Yates, 2013; Yilmaz, Ren, Custer & Coleman, 2010). Findings show that outreach programs targeted at the high school level generally raise awareness, and yield more interest in engineering.

Another factor to increase student interest in STEM is parents. According to a 2009 survey by the American Society for Quality, only 20% of parents encourage their kids to go into engineering. The same survey indicated that 44% of k-12 school students do not know a lot about engineering. This increases the importance of outreach programs for recruitment, and for raising awareness of school students regarding engineering, and STEM fields in general.
By the time students get to college, it is likely too late to increase their interest in STEM fields; even freshmen who are undecided are not very likely to go into engineering (Boesdorfer and Staude, 2016). Addressing STEM recruitment at the middle and high school levels could raise awareness, and get more students interested in STEM at an early age, before they get to college, when it is often too late (Aschbacher, Li, & Roth, 2010).

**Purpose and Objectives**

The purpose of this study is to examine the effect of attending a one-week summer engineering camp on middle school students’ interest to pursue a career in STEM fields. Additionally, the study aims at finding the major influences that are associated with the students’ interest. Finally, the study looks at the effect of a summer engineering camp on parents’ perception of STEM fields.

The study pursued the following objectives:

1. Determine if there is a significant difference between students’ interest in STEM fields before and after attending a week-long engineering summer camp with a special focus on students who start the camp with low interest.

2. Determine which factors, if any, are correlated with students’ interest in STEM fields. Those factors include gender, ethnicity, STEM involvement, parents’ perception of STEM fields, the socio-economic status and education of parents, and peer attitudes towards STEM fields.

3. Determine if parents’ perceptions of STEM are affected by their child attending a one-week summer camp.
**Research Questions**

The study is guided by the following research questions:

1. Does a summer engineering camp experience affect the perceived level of interest of secondary school students in STEM fields, especially those who enter the camp with a low perceived interest level? And how does it affect their interest?

2. What factors influence students’ interest, or lack of interest, to pursue a career in STEM fields?

3. How does a summer engineering camp experience attended by their child affect parents’ perception of STEM fields?

**Research Method**

This study used an experimental concurrent mixed methods design to answer the research questions. The participants in this study were middle school students in the eighth grade, as well as their parents. Two groups of students participated in the study over the course of two weeks in July 2017.

The dependent variable is interest in STEM fields, while the independent variables include gender, STEM involvement, socio-economic status and education of parents, parents’ perception of STEM fields, and peers attitudes towards STEM fields.

Both dependent and independent variables were measured via pre and post intervention surveys. The parents completed pre-intervention surveys before sending their children to the camp. Students completed a pre-intervention survey upon arrival to the camp, and completed daily journals during the camp. At the end of the camp, students
completed post-intervention surveys. Finally, parents completed post-intervention surveys once their child returned home from the camp.

**Definition of Terms**

*Descriptive Statistics:* Used to describe or summarize a collection of data quantitatively. These analyses typically involve measures of central tendency and dispersion augmented by graphical plots.

*Engineering:* The profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind (ABET).

*GEARUP STARS Project:* Utah State University’s Gaining Early Awareness and Readiness for Undergraduate Programs Science Technology Arithmetic Reading Students.

*STEM:* The disciplines of Science, Technology, Engineering, and Mathematics.

*STEM Education:* The study and educational enterprise of STEM.

**Limitations of the Study**

The limitations in this study are:

1. The statistical sample was taken from school districts in Utah that are members of the GEARUP program, and the sample may not be representative of the entire country, and results may not be generalizable.

2. Students who participated in the camp did so voluntarily, and thus may begin the camp with a high initial perceived interest in STEM. A better sample would include students who are interested, and those who are not interested. However, students who are not interested in STEM are not
likely to volunteer for a week-long camp. This is similar to the observation by Aschbacher, Ing, & Tsai (2014).

3. The number of students that was expected to participate in the camp was 60, but due to various reasons, outside the control of the researcher, only 40 students participated. Of those students, only 33 completed informed consent to participate in the research.

Assumptions of the Study

This study was conducted with the following assumptions:

1. Students and parents were open and honest when completing surveys, and answering open-ended questions.

2. The week-long camp was more or less identical between the two weeks, and the research team administered the activities to both groups of participants in the same way.
Chapter II

Literature Review

Current trends in education focus on increasing interest in science, technology, engineering, and mathematics (STEM) fields. There is a need for STEM trained workers in a variety of fields in order to strengthen the workforce, and support a strong economy (U.S. Congress Joint Economic Committee, 2012). A problem facing STEM education is the concern over the availability of STEM workers. The head of the Indicators and Analysis Division of the Organization for Economic Cooperation and Development (OECD) indicated that only countries with STEM-literate populations would be ready to compete in the current international market place (Schleicher, 2007).

Policymakers and scholars stress the importance of the creativity and innovation based on research and development in STEM fields as essential for economic growth, and global competitiveness. Highly skilled STEM workers are not only responsible for advancing basic scientific knowledge, but also to transform this knowledge into tangible and useful products and services. As a result, these workers make valuable contributions to improving the quality of living standards, and accelerating a nation’s economic growth. (National Science Board, 2016).

However, one of the main problems facing STEM education at this time is that U.S. businesses frequently have concerns over the availability of STEM workers. This is especially important, as over the past 10 years, the growth in STEM jobs is three times that of growth in non-STEM jobs. Interestingly, the issue of the lack of graduates in STEM fields is persisting, despite the higher pay and lower unemployment rates, compared to non-STEM fields (Langdon et al., 2011).
In addition, the number of STEM graduates in the United States is lagging behind other major competitors in the global economy such as China and India. Statistics show that the USA contributes around 4% of the total engineering graduates worldwide compared to 34% for China and 17% for Europe (The National Science Board, 2012).

According to the National Science Board, bachelor’s and equivalent degrees in STEM awarded in 2014 totaled more than 7.5 million worldwide (The National Science Board, 2018). Almost half of these degrees were in two Asian countries: India having a 25% share and China with 22%; another 12% were in the European Union and in the United States the share was 10%. University degree production in China has grown faster than in other major developed nations, and regions as can be seen in Figure 2 below. Between 2000 and 2014, the number of S&E bachelor’s degrees awarded in China rose more than 350%. This is significantly higher than the growth rate in the United States and many European and Asian countries (The National Science Board, 2018).

According to Drew (2015), one of the reasons behind this rapid growth is because most students in China learn advanced mathematics while in the United States only a few students do that. Additionally, in China everyone is considered capable of learning advanced concepts while in America there is the concept of aptitude and that not everyone has the innate ability to learn advanced mathematics.

Additionally, starting in 1999, China’s government launched a program to massively increase university attendance and as a result, the number of universities in China increased from 1,022 in 2001 to 2,824 in 2014 (National Bureau of Statistics of China, 2018). Moreover, the American Institute of Physics wrote a report discussing that while the U.S. continues to produce a large share of the world’s science and engineering
workforce and publications, China has continued to produce more than the U.S. as it greatly ramps up its research and development spending (Wolfe, 2018).

*Figure 2. Bachelor’s Degrees awarded in Science and Engineering in Selected Countries and Regions (National Science Board, 2018)*

EU-Top 8 includes the eight EU countries with the largest numbers of bachelor's degree awarded in 2014. This includes: United Kingdom, Germany, France, Poland, Italy, Spain, Romania, and the Netherlands.

While countries have different definitions for what constitutes a degree in Science and Engineering, the international higher education data have a higher degree of international comparability than in the past. This is due to a few factors such as the data for the majority of the countries were collected under the same Organization for Economic Co-operation and Development (OECD), European Union, and UNESCO
Institute for Statistics guidelines. While not perfect, this gives a reasonable comparison between how much each country produces in terms of Science and Engineering graduates, and is based on the Science and Engineering Indicators report by the National Science Board (2018).

Between 1960 and 2013, the number of workers in STEM fields grew at an average rate of 3% annually, compared to 2% annual growth rate for the entire workforce. Additionally, even during tough economic times, such as the 2008 recession, STEM employment continued growth. Between 2008 and 2014, the number of workers in STEM fields increased by about half a million, while the total workforce stayed relatively steady. (National Science Board, 2016).

During the last recession, the unemployment rate for STEM workers rose from 1.8% in 2007 to 5.5% in 2009 before going down to 5.3% in 2010. By comparison, the unemployment rate for non-STEM fields rose from 4.8% in 2007 to 9.5% in 2009 and then continued to increase to almost 10% in 2010 (Langdon et al., 2011). In 2013, unemployment in STEM fields dropped to 3.8% while overall unemployment for the entire U.S. labor force was at 8.1% (National Science Board, 2016). Additionally, workers in STEM fields earn more on average than workers in non-STEM jobs. Half of the workers in STEM occupations earned $81,000 or more in 2014. This is more than double the median salary of ($36,000) of the entire workforce in the U.S. (National Science Board, 2016). This is very interesting because even though STEM workers earn more on average, and are more in demand with lower unemployment rates, there is still a lack of graduates in those fields.
Looking at recent data, out of the 3.2 million high school graduates in 2012, among first year students, the enrollment in STEM fields was 17.9% of the total high school graduates that year with the percentages being 26% male and 11.7% female enrolling in STEM fields out of all high school graduates. In engineering, the numbers are even more bleak, with 4.9% of high school graduates in 2012 enrolling in engineering, with the percentages being 9.2% male and 0.9% female enrolling in engineering (National Science Board 2016). According to the National Science Board, out of those 4.9% enrolling, only about half of those will graduate with an engineering degree.

Additionally, looking at the number of bachelor’s degrees awarded between 2004 and 2014, the number of STEM bachelor’s degrees awarded in 2004 was 458,658, and in 2014 it grew to 635,915, with a growth rate of about 27%. Comparatively, non-STEM fields graduated 958,763 in 2004 and 1,255,026 in 2014 with a growth rate of about 24% (National Science Foundation, 2016).

While the growth rate for the bachelor’s degrees awarded in STEM fields is slightly higher than non-STEM fields, according to the Economics and Statistics Administration, during the same period, growth in the job market of STEM fields was 3 times that of non-STEM fields. STEM jobs in the U.S. are projected to grow by 17% between 2008 and 2018 (Langdon et al., 2011). Additionally, the most recent data from the Bureau of Labor Statistics projections, for the period 2014–24, show that total employment in occupations, that NSF classifies as S&E, will increase at a faster rate of 11%, than employment in all occupations at 7% (National Science Board, 2018). Moreover, The President’s Council of Advisors on Science and Technology indicated
that over the next decade there will be one million technical job openings in the United States that need to be filled, which will be a problem due to the low interest in STEM fields (PCAST, 2010).

The shortage in STEM professionals is a problem that is also present in many other developed countries, including the UK, Canada, Germany, Austria, Belgium and Poland. (Business Europe 2011, Royal Academy of Engineering 2012, Franz-Odendaal, Blotnicky, French, & Joy, 2016 and Doerschuk, Bahrim, Daniel, Kruger, Mann, & Martin, 2016).

Compounding the problem of a lack of STEM graduates is attrition, or the low retention rates for students in STEM majors, especially engineering. This means that many of the students that actually do go into engineering end up switching to other majors. According to Santiago (2013), the percentage of students switching majors is quite high; 40% up to 60% of engineering students switch majors, or even drop out of college altogether.

The main reasons for switching majors seem to be the lack of interest in engineering, as well as the difficulty of the academic content that they have to deal with and study (Santiago, 2013). There is a lot of effort and resources being poured into the retention problem, but unfortunately, those have been met with little success so far (Melsa, 2007; Veenstra & Herrin, 2009).

Interestingly, a lot of students switch from engineering to other fields, as much as 40 – 60% as mentioned earlier. However, very few, around 7%, switch from other fields into engineering (Ohland et al., 2008). This makes the retention problem even worse, and
the need for outreach programs to recruit more students into engineering an even more pressing matter.

Recent research by Ohland et al. (2008) indicates that there is less than 10% migration into engineering majors from other fields. Thus, the pool of graduating engineers comes mostly from the students choosing engineering from the beginning of their college years. Many of these students were influenced by their parents to consider an engineering career. Since not many students transfer into engineering, mentoring the current students to stay and persist in engineering is important for addressing the current shortage of engineers.

**Underrepresented Minorities**

In addition to a lack of students in STEM fields as a whole, STEM education is underrepresented with minorities. Some ethnic groups, and women, are underrepresented, especially in engineering, and this contributes to the lack of STEM graduates.

**Gender.** According to Archer et al. (2013), there is widespread concern about the need to increase participation in the sciences (particularly the physical sciences), especially among women. According to data from the U.S. census bureau, 50.8% of the current population is female and 49.2% are male. (U.S. Census Bureau, 2015). The latest data from the U.S. census bureau shows that participation and success rates of men and women in secondary, and higher education, are mostly even. In fact, in the last couple of decades, women have received more bachelor’s degrees than men; 33% compared to 32% for men (Ryan and Bauman, 2016). In all fields, in 2014, females were awarded 57.2% of all bachelor degrees (National Science Foundation, 2016).
However, this trend does not apply to some STEM fields. As a whole, women were awarded 50% of all STEM degrees in 2014, which is down from 50.3% in 2004. This data includes psychology and the social sciences. Looking at some specific STEM fields such as the physical sciences, computer sciences and engineering, the participation rates are much lower at 39.7%, 18.1% and 19.8% for those fields respectively in 2014. Those numbers are down from 42.2%, 25.1% and 20.5% in 2004 (National Science Foundation, 2016). This means that not only is women’s participation in those STEM fields low, it has also been on a decreasing trend in the past decade. This is shown in Figure 3.

![Figure 3. Women’s share in Science and Engineering degrees awarded by field.](image)

(National Science Board, 2016)

For engineering specifically, Figure 4 shows the percentages of women intending to go into engineering, and degrees awarded 6 years later. Less woman than men, with
intentions to go into engineering, actually graduate with an engineering degree six years later.

Figure 4. Engineering: Freshmen intentions and degrees six years later, by sex (National Science Board, 2016)

One of the issues women face that contributes to the declining numbers is a lack of similar role models. Men comprise the majority of STEM faculty at universities in the United States, and this may signal to women that they do not belong (Herrmann, Adelman, Bodford, Graudejus, Okun & Kwan, 2016). Looking at statistics in 2012, women made up 41% of doctoral degree recipients, 32% of postdoctoral fellows, and 37% of faculty in STEM fields (National Science Foundation, National Center for Science and Engineering Statistics, 2015). Looking at engineering specifically, there were 15,000 employed female Ph.D. holders in the U.S. compared to 92,000 males in 2015 (National Science Foundation, 2016). This clearly indicates a lack of similar role
models for females, as most faculty members in engineering are male (Herrmann et al., 2016).

Additionally, when it comes to role models, among the doctoral degrees awarded in the United States in 2014, women only accounted for 18.7% in physics, 20.8% in computer science, and 22.8% in engineering. On the other hand, in non-Science and Engineering fields, women were awarded 61.6% of all doctoral degrees. (National Sciences Foundation, 2016)

Looking at specific numbers in the workplace, for all Science and Engineering occupations, there are 1.8 million employed women with Science and Engineering degrees including social science and psychology compared to more than 4.5 million males. For engineering occupations specifically, there are 250,000 females employed in engineering in the U.S. compared to 1,469,000 males (National Sciences Foundation, 2016).

In addition to a lack of similar role models in STEM fields, there are other reasons women are not interested in going into some STEM fields. Some of these include, not feeling welcome in the STEM environment, not encouraged or expected to succeed in those fields (Lambright et al., 2009), or the misconception that engineering is a ‘nerdy’ career (Borrego & Bernhard, 2011).

Knezek, Christensen, & Tyler-Wood (2011) argued that the gender gap in STEM is less of an ability gap, than a gap in perceptions of science careers. Dubetz and Wilson (2013) found that middle school girls mentored by female role models during university-based summer outreach activities developed greater interest in science, mathematics and higher education while being introduced to potential STEM career opportunities.
An in-depth study was conducted by Archer et al. (2013) based on data collected from a five-year longitudinal study of children’s science aspirations and career choices to identify why many girls may see science fields as ‘not for me’. Their results are based on interviews with 92 girls and 78 parents, focusing on those girls who had low interest in science. Their findings concluded that those girls have very low interest in science careers because they do not fit with either their understanding of desirable/intelligible femininity, or with their sense of themselves as learners/students. The authors found that those girls view science careers as ‘clever’/’brainy’, ‘not nurturing’ and ‘geeky’. Those views are in direct contrast to those girls’ identities as ‘normal’, ‘ girly’, ‘caring’ and ‘active’ (Archer et al. 2013).

Even the girls in their study that were interested in science felt different among their classmates. Additionally, the study showed the girls with low interest in science had career aspiration in two categories: ‘nurturing’ such as elementary education or childcare, which were viewed by both girls and their parents as ‘good jobs’. The other category was ‘glamorous/girly’ jobs such as those in fashion, show business and modeling. When asked to explain why they were interested in those jobs, the girls discussed links between femininity and ‘caring’ and they frequently named specific female family members and teachers, who had nurturing roles, as role models that they admired and wanted to be like in the future. They also found that the majority of parents in their study thought that science careers are associated with masculinity and perceived science as being an area that more men than women study and work in (Archer et al., 2013).

From the lack of interest in science among the girls in Archer’s study, it was clear that those girls did not think science careers would give them the opportunity to be in
nurturing or caring roles. The author’s recommendation was to increase teachers’, families’ and children’s awareness of the wide variety of career options in science (Archer et al., 2013).

**Ethnicity.** As with the lack of women in STEM fields, there is also an ethnic diversity problem, with a lack of graduates in STEM from underrepresented minorities, mainly Hispanics, African Americans and Native Americans. When it comes to the U.S. current population, the ethnic distribution is 62.1% white, 17.4% Hispanic, 12.4% African American and 5.3% Asian (U.S. Census Bureau, 2015).

However, representation of those ethnic groups in STEM fields are not proportionate to their representation in the overall population. For example, Hispanics and African Americans are almost 30% of the total population, but represent a much smaller proportion of the STEM workforce: 14% of STEM highest degree holders and 11% of workers in STEM occupations. On the other hand, Asians make up 5% of the U.S. population, but account for 17% of those employed in STEM occupations. Asians have a large presence in engineering and computer sciences occupations (National Science Board, 2016).

About 70% of workers in STEM occupations are white, which is comparable to their overall representation in the U.S. population (62%). Foreign-born individuals account for 27% of all workers in STEM occupations, which is substantially higher than their share of the entire college-educated workforce at 15% (National Science Board, 2016).

Looking at statistics of the number of Bachelor’s degrees awarded in all Science and Engineering fields for all ethnicities in 2014, 635,915 bachelor’s degrees were
awarded. Of those, whites obtained 58.6% of the degrees, which is comparable to their share of the entire population at 62.1%. Hispanics were awarded 11.5% of degrees, which is substantially less than their share of the population at 17.4%. Similarly, African Americans were awarded 8.2% of degrees, which is also substantially less than their share of the population at 12.4% (National Science Board, 2016). For engineering specifically, Figure 5 shows the percentages of students from each ethnicity intending to go into engineering, and then degrees awarded 6 years later. For African Americans, less than one third of those freshmen with intentions to go into engineering, actually graduate with an engineering degree six years later compared to about three fourths for White or Caucasian students and about two thirds for Hispanic students.

*Figure 5. Engineering: Freshmen intentions and degrees six years later, by race and ethnicity (National Science Board, 2016)*
STEM Recruitment and Outreach Programs

Regardless of the reasons why some ethnic groups and women have less interest in STEM, it is very important to design interventions to increase participation of those groups.

Outreach programs to schools is one of the methods often used, and findings suggest that outreach programs are effective, especially on elementary school students (Johnson et al., 2013). There is extensive literature about the topic of outreach programs for recruiting young minds from the K-12 education system into STEM.

Laut et al. (2015) believe that STEM recruitment is critical for the economy and society, and the results of their surveys show that students who participated in outreach program have more interest in going into STEM fields. Abaid et al. (2013) observed similar results, and they concluded that summer camps where students learn about engineering outside the school environment have been largely successful in increasing their interest in STEM fields.

In a study by Aschbacher et al. (2010), the authors found that none of the students in their study, who began tenth grade with moderate or low interest in science, developed a stronger interest later on in high school. Several studies suggest that the middle school years are the time when students begin to make choices, such as what courses to enroll in, or how much effort to devote to these courses. Therefore, understanding middle school students’ perceptions regarding STEM is very important to preparing the future STEM workforce. Similarly, Knezek, Christensen, Tyler-Wood, & Gibson (2015) recommended STEM career intervention and outreach programs as effective tools to increase interest in STEM.
Yates (2013), and Babb et al. (2014) stressed the importance of STEM recruitment, and their findings were similar to other studies. They concluded that outreach programs, targeted at the high school level, generally raises awareness and yields more interest in engineering. Yilmaz et al. (2010) found similar results.

Weber (2011) recommends providing informal STEM-related learning opportunities for students to increase their interest in STEM, and their knowledge about those fields. According to Hiller & Kitsantas (2014), “Informal natural science learning settings, in which students emulate the behavior of professional scientists while conducting fieldwork, is a venue for promoting STEM careers that has been largely overlooked” (p. 302). Similarly, Friedman (2008) stated that informal science learning plays a very important role in promoting STEM fields.

Pittinsky & Diamante (2015) made an interesting observation. “We see kids of all genders and ethnicities express a lot of interest in STEM fields in elementary school, but that interest drops off precipitously in high school and college, as the work in those subjects gets harder.” (p. 47). According to their research, it seems that the problem begins when the fun stops. Their recommendation is, not tell students that STEM is fun, but to tell them that it’s challenging. This will make them feel a sense of pride and accomplishment when they succeed. (Pittinsky & Diamante, 2015).

Factors Influencing Children’s Career Choice

There is a lot of research discussing the factors that influence children’s career choice. According to Sahin, Gulacar, & Stuessy (2015), teachers, personal interests, and parents, mostly influence students’ career aspirations. Other factors they discussed based on the literature include; job security, personal interest, job satisfaction, difficulty levels...
of preparation courses and relationships-based influences from friends, parents and role models.

Franz-Odendaal et al. (2016) stated that the influences on children’s career choices include, dryness of the subject matter, parental influence, teacher influence, peer pressure, adolescence, lack of career awareness, and lack of the realization of the relevance of science education to their lives.

A recent college-level study sponsored by Microsoft Corporation (2011), found that students having a passion for STEM, and studying hard were the most important factors affecting their interest in STEM. The authors also found that external factors, including mentors and role models, were actually less important. Students’ choice to go into STEM majors were influenced by STEM fields, providing the potential for a good salary, as well as better chances of finding a job, and that those fields are intellectually stimulating and challenging.

According to a survey by the American Society for Quality in 2009, only 20% of parents encourage their children to go into engineering. The same survey indicated that 44% of k-12 school students do not know a lot about engineering. This shows the importance of outreach programs for recruitment, and for raising awareness of school students regarding engineering and STEM fields.

According to the President’s Council of Advisors on Science and Technology [PCAST] 2010), before entering the eighth grade, students decide that many of the STEM subjects are too challenging, boring, and/or uninteresting. This essentially limits their interest in participating in STEM activities, and in studying STEM fields. Additionally, many students view mathematics as either boring or very difficult. In fact, some students
even suffer from math anxiety (Gersten, Beckmann, Clarke, Foegen, Marsh, Star, & Witzel, 2009).

Regardless of the reason why there is a lack of students going into STEM fields, especially engineering, it is a real concern that needs a solution. In fact, one of the main goals for STEM education research is to increase the overall number of graduates in those fields, especially females. The ‘Engage to Excel’ report to the president in 2012 indicated that this is a national concern. Olson and Riordan (2012) state that the United States needs to produce one million more STEM graduates over the next decade than it is producing now.

While it is certainly a real problem that there is a lack of students participating in STEM, there are steps that can be taken to build up interest in STEM fields. There is a need to evaluate the effectiveness of hands-on projects in STEM fields on students’ interest (Knezek et al., 2015).

Current research findings indicate that STEM summer camps have been successful in motivating and increasing students’ interest in STEM disciplines and careers (Bachman, Bischoff, Gallagher, Labroo, & Schaumloffel, 2008; Davis & Hardin, 2013; Hayden, Ouyang, Scinski, Olszewski, & Bielefedlt, 2011; Mohr-Shoreder, et al., 2014; Nugent, Barker, Grandgenett, & Adamchuk, 2010; Yilmaz, Ren, Custer, & Coleman, 2010).

**Informal Learning**

Researchers define Informal learning environments in different ways. One of the definitions puts it as environments outside the classroom or university, where learning takes place (Sullenger, 2006).
Similarly, other definitions put it as learning taking place outside the classroom (Maarschalk, 1988; Tamir, 1990). The Academic Competitiveness Council reported that informal education is one of the important elements of the United States’ educational system, which may help raise the number of citizens literate in STEM (U.S. Department of Education, 2007). Informal education is also seen as a fundamental pipeline for increasing the interest, understanding, and appreciation toward STEM (National Science Board, 2007).

Informal learning can take many different forms. This includes field trips, science fairs and museums, after school programs and summer camps (Sahin, 2013; Sahin, Ayar, & Adiguzel, 2014). Evidence suggests that informal learning environments, as well as the hands-on activities associated with it increases students’ interest, motivation and engagement in STEM (Ricks, 2006; Sawyer, 2006).

The National Research Council suggests that informal science learning is one of the ways of increasing STEM interest in students (National Research Council, 2011). The National Research Council also suggests some examples for those informal STEM learning opportunities to include visits to museums, zoos, afterschool clubs, and academic competitions (National Research Council, 2009). Additionally, informal science education experiences often “grab learners’ attention, provoke emotional responses, and support direct experience . . .” (National Research Council, 2009, p. 42). Recent leaders in informal learning, as it relates to STEM fields, have called for professionals in informal science education, and k-12 STEM teachers, to work together in the effort to improve STEM literacy and participation (National Research Council, 2009; Stocklmayer, Rennie, & Gilbert, 2010).
A recent report by the National Research Council (2015), suggests that the ways in which young people learn about the fields of STEM has changed significantly in the past decade. Today, young people have more opportunities to learn about STEM in a wide variety of settings, including clubs, summer programs, museums, parks, and online activities.

According to the North American Association for Environmental Education (2008), participation in outdoor learning programs, has a positive effect on student academic achievement. Informal natural science learning environments, where students are tasked with behaving and thinking like professional scientists as they conduct fieldwork, is a great resource in increasing student interest in STEM careers that has been largely overlooked. (Hiller and Kitsantas, 2014)

An informal learning environment for a K-12 student, allows them to go into STEM in a way that they may or may not have experienced in their traditional school setting. The call for an increased interest in STEM has resulted in the creation in a lot of informal learning environments centered around STEM fields. These informal learning environments range from short experiences such as camp experiences, to camps held at schools or universities that last for a week or more (Mohr-Schroeder et al, 2014)

These STEM-specific informal learning environments share some common themes:

1. Increasing the interest of middle or high school students in STEM fields, by getting them more engaged, with the goal that they choose a STEM career.

2. Promoting summer STEM camps, especially to underrepresented minorities, and those with disabilities.
3. Using hands-on activities to help students experience STEM fields, similar to its real life applications. (Mohr-Schroeder et al, 2014)

Weber (2011) provided a similar recommendation, and suggested that informal STEM-related learning is an effective strategy to expand students’ interest in and knowledge about STEM fields.
Chapter III

Methodology

This study examined the effect of attending a one-week engineering summer camp on middle school students’ interest to pursue a career in STEM fields, with the aim of finding the major influences that are associated with the students’ interest. Additionally, the study looked at the effect of a summer engineering camp on parents’ perception of STEM fields. Although the effects of engineering camps is well documented, this research aimed to look further into less studied aspects of STEM recruitment, such as the effect of those kinds of camps on students that begin the camp with low interest in STEM, as compared to students who start with high interest. Additionally, this research aimed at studying the effects of some factors on students’ interest; this included their parents, their friends, and their engagement in STEM.

This research used experimental concurrent mixed methods as outlined by Creswell and Clark (2010), Creswell (2013) and Borrego, Douglas, & Amelink (2009). Quantitative data was collected via survey instruments, before and after the intervention, to both students, and their parents. The validated surveys are based on the work of multiple researchers, and is detailed below. Qualitative data was collected via open-ended questions, as well as student journals completed on a daily basis during the week-long engineering summer camp.

Research Questions

The study was guided by the following research questions:

1. Does a summer engineering camp experience affect the perceived level of interest of secondary school students in STEM fields, especially those
who enter the camp with a low perceived interest level? And how does it affect their interest?

2. What factors influence students’ interest, or lack of interest, to pursue a career in STEM fields?

3. How does a summer engineering camp experience attended by their child affect parents’ perception of STEM fields?

Participants

The sample for this study included 33 student participants, as well as their parents. The participants were eighth grade students going to ninth grade. All were in Utah school districts, served by the GEAR UP STARS program. Students in those schools, were invited via flyers (Appendix A), as well as their science teachers advertising the camp in their classes. The number chosen to participate was based upon the capacity of the facilities at Utah State University (USU), and the ability of the camp facilitators, to provide sufficient individualized attention. Because of the intense nature of the activities by participants, and the mentorship requirements of program facilitators (faculty, graduate students, and undergraduate student mentors), the participant pool was limited to 70 (60 students, 10 teachers), with a target student to teacher ratio of 6:1. However, due to various factors outside the researcher’s control, only 40 students participated, and of those, 33 had signed informed consent forms to participate in the research. Additionally, parents were not very responsive with filling out the surveys, and out of 60 parents, only 38 filled the pre-survey, and 24 filled the post-survey. This amounts to response rates of 63% and 40% respectively. However, a response rate of at least 30% to
surveys is considered satisfactory, according to the guidelines established by the Instructional Assessment Resources (2011).

Surveys were sent to the parents, both in paper form, by mail, and electronic form, using the Qualtrics survey service used by USU.

**Statistical Power for Survey Instrument and Generalizability**

The nature of this research has students volunteering to participate. This explains their high initial interest in STEM (Aschbacher et al., 2014). Additionally, the GEAR UP program targets students from low-income families. Those two factors indicate that the sample is not random, or representative of the total population of Utah, or the United States of America. Thus, the data cannot be generalized to the population of Utah, or the United States, and thus inference statistics will only explain the trends, and differences between pre and post camp data, and will not be used to draw inferences about the population (Hayter, 2012).

**Institutional Review Board (IRB)**

This study sought Institutional Review Board (IRB) approval from USU. An IRB form was submitted on March 22nd, 2017 and was approved on May 5th, 2017. The study took place in July, 2017 on the USU campus, with assistance from the GEAR UP STARS team, teachers from the participating schools, as well as engineering faculty, and research assistants. Letters of consent and youth assent documents for participating students and their parents, were obtained (Appendix B). All documents and surveys were translated to Spanish, as some of the population served by the GEAR UP STARS program is Spanish speaking only. The student participants were informed that they would be able to withdraw from the research at any time without any repercussions.
Program Description

Students and science teachers from multiple school districts in Utah, were invited to attend a week-long summer engineering camp, designed to increase their interest in STEM. This engineering camp is part of a 7-year $34 million grant funded by the Department of Education, as part of the GEAR UP program. The grant’s overall goal is to help more than 3,000 middle and high school students’ to improve their academic achievement, creating a pipeline of academically prepared students to enroll, and excel in college. During the summer camp, teacher and student participants developed engineering research hypotheses, tested those hypotheses, and thought like engineers. Participating teachers applied the research, and engineering camp activities, to develop classroom lessons for their science classroom, to meet the Next Generation Science Standards (NGSS) framework, which has engineering as a fundamental component.

The program was designed to promote hands-on learning, with little passive classroom learning. The main theme of the engineering camp was water and environmental engineering. Before the camp activities started, students completed a pre-camp survey to determine their perceptions of, and interest in STEM. The same survey was given to students at the end of the engineering camp, to determine the impact the camp experience had on improving the student’s perception, and increasing their interest in STEM.

Table 1 below shows a summary of the activities students and teachers engaged in during the week-long engineering camp.
Table 1

Outline of the week-long engineering camp

<table>
<thead>
<tr>
<th>Day</th>
<th>Activity 1</th>
<th>Activity 2</th>
<th>Activity 3</th>
<th>Activity 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>Water Cycle</td>
<td>Fish tagging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuesday</td>
<td>Measuring water properties at multiple locations along a local river, starting upstream and then going all the way downstream.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wednesday</td>
<td>Water Run off experiment</td>
<td>Storm water impacts/multiple location</td>
<td>River Dye activity</td>
<td>Building and testing a water filter</td>
</tr>
<tr>
<td>Thursday</td>
<td>Looking at bacteria under a microscope</td>
<td>Site visit to a local lagoon treatment facility, sampling and analysis of water quality parameters</td>
<td>Site visit to a local mechanical waste water treatment facility, sampling and analysis of water quality parameters</td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td>Poster Session</td>
<td>Presentation Session</td>
<td></td>
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</tbody>
</table>

The first day of the engineering camp included activities to pique the students’ interest in STEM, and related to water resource management. The day began with an activity showing students the water cycle to illustrate the amount of available fresh water for human use in the hope of increasing their appreciation for the scarcity of usable water. The results of this activity showed up many times in the daily journals students wrote as they learned more about the importance of water conservation. A fish tagging activity followed the water cycle activity. This included the fish tagging process, the importance of it, and how scientists and engineers use the process to determine the health of streams and movement of fish in the stream. With the aid of a graduate student in Fisheries...
Biology, students had the opportunity to engage in the practice of tagging fish. Table 2 below shows the objectives and learning outcomes from the first day’s activities.

Table 2

*Objectives and learning outcomes for the first day’s activities*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Objectives</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Water Cycle</td>
<td>Students will be able to describe the “expanded” water cycle, discuss how little useable water is available to us and participate in a game that shows the pathways that a water molecule travels in.</td>
<td>Moving from the simplified water cycle and replace that with the more complete picture of water pathways, understanding the scarcity of useable water and playing a game that shows how water molecules travel from one reservoir to another.</td>
</tr>
<tr>
<td>Fish Tagging</td>
<td>Students will be able to tag a fish, identify the various types of tags and explain why fish tagging is important.</td>
<td>Understanding the process of fish tagging as well as its importance.</td>
</tr>
</tbody>
</table>

During the second day of the engineering camp, students visited three sites along the Logan River in the local water shed. The first stop was upstream in the mountains where melting snow fed the river. The second stop was downstream of camping, fishing, kayaking and other recreational uses of the water at a point just before the river enters the city. The final stop was after the river had passed through the city, farms and ranches in the area. At each stop, students took various physical and chemical measurements of the water including temperature, flow velocity and volume, dissolved oxygen, turbidity, and nutrient concentrations including phosphates and nitrates. The students also collected and characterized macro invertebrates living in the river. The point of this activity was to show the students what happens physically, chemically, and biologically to the water as it flows downstream, passes through a city, and changes in response to the influence of
human civilization. Table 3 below shows the objectives and learning outcomes from the second day’s activities.

Table 3

Objectives and learning outcomes for the second day’s activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Objectives</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring water properties at multiple locations</td>
<td>Students will be able to measure various properties of water such as dissolved oxygen and nutrients present. Students will also be able to capture and categorize macro-invertebrates that live in streams. Students will also be able to understand the differences in water properties between areas upstream and downstream from human populations and how the water changes in response to the influence of human civilization.</td>
<td>Understanding how to measure water properties as well as the importance of measuring stream properties and the health of a stream.</td>
</tr>
</tbody>
</table>

The third day of the engineering camp focused on storm water impacts, and water treatment. This included a simulated storm water activity, comparing runoff volume and intensity as rainfall was simulated on an area covered in vegetation, and another area covered with asphalt/concrete, to show the potential impact of urban development (increases in impervious surface areas). The students then visited a parking lot storm water system at a local chain box store and observed the plants used to filter pollutants running off the parking lot, such as oil and gas. Those pollutants are washed away by the rain, but before the water enters the storm water system, it passes through a thick vegetation area and is cleaned by specialized plants. Students also had the opportunity to see what happens as a non-reactive fluorescent tracer (simulated pollution) is dumped into the local River, and observed how fast and how far pollution can spread. Finally,
teams of students competed at building a water filter from sand and gravel. Faculty and student researchers judged the quality of the filters based on the clarity of the filtered water as well as the speed at which the filter worked. Table 4 below shows the objectives and learning outcomes from the third day activities.

Table 4

Objectives and learning outcomes for the third day's activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Objectives</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Run off experiment</td>
<td>Students will be able to simulate rainfall on a natural and urban surfaces. Students will also be able to understand the potential impact of urban development.</td>
<td>Understanding the effect of urbanization on storm water run-off and the ability of the ground to naturally absorb some of the rainfall.</td>
</tr>
<tr>
<td>Storm water impacts/multiple location</td>
<td>Students will be able to explain the importance of filtering plants used in the parking lots of chain stores and the role they play in cleaning water run-off from parking lots</td>
<td>Understanding the importance of filtering plants used in parking lots.</td>
</tr>
<tr>
<td>River Dye activity</td>
<td>Students will understand the role water can play in spreading pollution quickly and through long distances.</td>
<td>Understanding running water’s ability to spread pollution very effectively and why water should be monitored carefully to prevent that from happening.</td>
</tr>
<tr>
<td>Building and testing a water filter</td>
<td>Students will be able to build and test a basic water filter made from a plastic bottle, gravel and sand.</td>
<td>Understanding the simplest form of water filtration and how even basic items available everywhere can be used as a good first step to clean water.</td>
</tr>
</tbody>
</table>

The **fourth** day of the engineering camp focused on wastewater treatment facilities. Students looked at bacteria under the microscope, and saw some of the bacteria that are at work at biological treatment plants, such as those they would visit later that
day. After learning about bacteria related to treatment plants, students visited a local treatment lagoon, and wetland system, that filters the water of the surrounding county, and then visited, and sampled, and analyzed water quality parameter at another mechanical treatment plant. The students learned the differences between the two treatment methods; natural and mechanical, as well as the advantages and disadvantages of each. Table 5 below shows the objectives and learning outcomes from the fourth day’s activities.

Table 5

**Objectives and learning outcomes for the fourth day’s activities**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Objectives</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Looking at bacteria under a microscope</td>
<td>Students will be able to identify various types of bacteria that is used in treatment plants to biologically treat the water.</td>
<td>Understanding the role bacteria plays in wastewater treatment plants.</td>
</tr>
<tr>
<td>Visit to the local lagoon treatment plant</td>
<td>Students will be able to explain the natural treatment method used at lagoon treatment plants.</td>
<td>Understanding the differences between natural and mechanical treatment plants as well as the pros and cons of each.</td>
</tr>
<tr>
<td>Visit to the local mechanical treatment plant</td>
<td>Students will be able to explain the mechanical treatment method used at mechanical treatment plants.</td>
<td></td>
</tr>
</tbody>
</table>

During the **final** day (Day 5) of the engineering camp, students presented what they had learned in a team poster session, followed by a team presentation session. Finally, students completed a post-survey to gauge their interest gains in STEM through the camp. Table 6 below shows the objectives and learning outcomes from the final day’s activities.

Table 6
Objectives and learning outcomes for the final day’s activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Objectives</th>
<th>Learning Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poster Session</td>
<td>Students will be able to present their work to the rest of the group as well as the faculty and student researchers involved in the camp.</td>
<td>Understanding the importance of working as part of a team for scientists and engineers as well as the importance and value of presenting one’s work.</td>
</tr>
<tr>
<td>Presentation Session</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

One of the main objectives of the camp was to teach students how to think like scientists and engineers. The goal was to have students develop a research question and/or a hypothesis related to the camp activities on the second day of the camp. On the third and fourth days, students worked on analyzing the data they collected while participating in their daily activities. The students worked as a team, with the guidance of a teacher, to develop a poster, as well as a presentation, to show their research hypothesis, how they would design an experiment to test that hypothesis, as well as their thoughts about what to expect from such an experiment.

Additionally, regarding curriculum alignment in science, the camp activities aligned with the Utah Science with Engineering Education (SEEd) standards. Particularly strand 6.4, which discusses the stability and change in ecosystems. This strand focusses on the interaction of organisms with each other and their environment, the availability of resources, and how that affects the organisms living in that environment, as well as the stability of populations when affected by changes in an ecosystem. (Utah State Office of Education, 2015)

Many of the camp activities, such as the water cycle, fish tagging, measuring water properties at various locations along a river, storm water impacts and water treatment, all align with this particular strand in the SEEd standards.
The GEARUP mentors who designed and delivered the activities are discussed in Table 7.

**Table 7**

**GEARUP Mentors who designed and delivered activities**

<table>
<thead>
<tr>
<th>Mentor</th>
<th>Degree/Major</th>
<th>Role in Camp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kurt Becker</td>
<td>Industrial Teacher Education</td>
<td>Coordination and supervision of camp activities</td>
</tr>
<tr>
<td>Nancy Mesner</td>
<td>Watershed Science</td>
<td>Design and delivery of camp activities</td>
</tr>
<tr>
<td>Ryan Dupont</td>
<td>Civil and Environmental Engineering</td>
<td>Design and delivery of camp activities</td>
</tr>
<tr>
<td>Max Longhurst</td>
<td>Teacher Education</td>
<td>Designing and delivering professional development for participating teachers</td>
</tr>
<tr>
<td>Murad Mahmoud</td>
<td>Engineering Education</td>
<td>Collecting data</td>
</tr>
<tr>
<td>McKenna Drew</td>
<td>Landscape Architecture and Environmental Planning</td>
<td>Designing and delivering activities</td>
</tr>
<tr>
<td>Jose Pacheco</td>
<td>Conservation and Restoration Ecology</td>
<td>Designing and delivering activities</td>
</tr>
<tr>
<td>Cole Patton</td>
<td>Conservation and Restoration Ecology</td>
<td>Designing and delivering activities</td>
</tr>
<tr>
<td>Hannah Johnson</td>
<td>Fisheries</td>
<td>Designing and delivering activities</td>
</tr>
<tr>
<td>D Wiley</td>
<td>Environmental Engineering</td>
<td>Designing and delivering activities</td>
</tr>
<tr>
<td>Avery Holyoak</td>
<td>Environmental Engineering</td>
<td>Designing and delivering activities</td>
</tr>
</tbody>
</table>

As can be seen in Table 7, most of the mentors were from Science and Engineering disciplines, and the activities students participated in involved engineering, science and math, but none of the mentors majored in technology, and none of the GEARUP activities focused entirely on technology. This could explain some of the results discussed in Chapters 4 and 5, which showed that students’ interest in technology,
did not increase significantly. This may be due to having no mentors that were technology specialists as all the mentors were from science and engineering backgrounds.

**Data Collection**

**Overview.** Qualitative and quantitative data was collected to assist in answering the research questions for this study. Quantitative data was collected via surveys administered before and after the camp, to both students and their parents. Qualitative data was collected via open-ended questions in the pre and post-surveys, as well as daily journals students completed during the week-long camp. The student survey is shown in Appendix C, the parent survey is shown in Appendix D, and the journal prompt is shown in Appendix E. The student and parent surveys are discussed in the following pages.

**Parents’ Pre and Post-Surveys.** Parents received the pre-survey and informed consent document before the students arrived to attend the camp. The parent survey was delivered before and after the camp. Separate surveys were sent to the father and the mother to obtain more data, as it was expected that not all parents would be willing to complete the surveys. Both survey and informed consent were available in Spanish. The pre-survey was sent to the parents using Qualtrics software on June 2\textsuperscript{nd}, e-mail reminders were sent on June 10\textsuperscript{th}, June 30\textsuperscript{th}, July 5\textsuperscript{th}, July 8\textsuperscript{th}, and July 11\textsuperscript{th}. Additionally, the pre-surveys were sent by mail on June 14\textsuperscript{th}. The post-survey was sent home to the parents in sealed envelopes with their children at the completion of the camp. Reminders to complete the post-survey were sent to the parents July 17\textsuperscript{th}, July 27\textsuperscript{th}, August 3\textsuperscript{rd} and August 12\textsuperscript{th}.

The pre and post-surveys contained questions about the parents’ perception of the importance of STEM fields, demographic questions, and an open-ended question; “What
are your thoughts on the importance of STEM (Science, Technology, Engineering and Mathematics) for the future of your son/daughter?” The survey was based on the work of Yun, Cardella, Purzer, Hsu, & Chae (2010), with questions such as, “I want my child(ren) to pursue a career in engineering.” As well as the work of Andre, Whigham, Hendrickson, & Chambers (1997) with questions such as, “On a scale of 5 to 1, with 5 being really important, how important are the following subjects/areas for your child in order to be successful at what he/she will be doing when he/she grows up?”.

Additionally, some questions were taken from the national STEM perceptions survey developed by Microsoft Corporation (2011), with questions such as, “Which of the following careers, if any, would you like your child to pursue? Which of the following, if any, do you think your child will want to pursue?” Following the question is a list of careers ranging from Engineer to Teacher to Professional Athlete. While these questions were included in the survey, the data was not used, and was not reported in the Results section of this document.

The survey also included demographic questions based on the work of Yun et al. (2010). The questions included the parents’ level of education, ethnicity, occupation and household income.

Qualitative data was obtained from the parents using an open-ended question: “What are your thoughts on the importance of STEM (Science, Technology, Engineering and Mathematics) for the future of your son/daughter?” This question was added to shed light on the parents’ perceptions of STEM, and is based on the recommendation of Sahin et al. (2015), that using open-ended questions can be used to achieve more insight into
the question, and combat the limitations of Likert scale items. The parent survey is available in Appendix D.

Upon returning home from the engineering camp, it was expected that the children would talk to their parents about the week-long experience. However, to give parents more of an idea of what is going on throughout the camp, parents had access to a camp blog that was updated daily. The blog included a short description of the activities of the day, photos and videos of the day, as well as a link to all the photos/videos taken that day. The blog also contained quotes taken from the students’ daily journals. The combination of the children talking to their parents about their experience after the engineering camp, as well as the daily blog, may have had an effect on the parents’ perceptions of STEM fields. The blog is based on work by Mohr-Schroeder et al. (2014). The blog is available at the link https://eed.usu.edu/gearup/gear_up_star

Parents completed a post-survey after the camp. It was delivered to the parents by their child, in an envelope with a return address and postage, so it could be completed, and sent back. Additionally, parents had the option to fill the survey online, if they preferred. Several reminders were sent after the camp.

**Students’ Pre and Post-surveys and journals.** The first day students arrived at the camp they completed a pre-survey, which contained demographic questions and the STEM-CIS Career Interest Survey, based on the work of Kier, Blanchard, Osborne, & Albert (2014). This survey measures the attitudes and interest of students towards STEM fields and has four sections, each pertaining to one part of STEM. Each section includes 11 questions, for a total of 44 questions. The STEM CIS includes questions such as, “I
am interested in careers that involve engineering”. The survey is a 5-point Likert scale from ‘Strongly Agree’ to ‘Strongly Disagree’.

Based on the data collected from the STEM CIS survey, correlations were examined between the level of interest, and various factors that possibly influence student interest such as gender, parents’ perceptions, friends’ attitudes and level of STEM engagement, as discussed in the literature review. Analysis of the data is discussed in the analysis section.

The student survey also included four questions regarding peer attitudes toward science, as discussed previously in the literature review. Those four questions were based on the work of Talton and Simpson (1986), and included questions such as, “My best friend likes science.” Those questions are a 5-point Likert scale from ‘Strongly Agree’ to ‘Strongly Disagree’.

Additional questions were drawn from the work of Franz-Odendaal et al. (2016), and targeted students’ level of engagement with informal STEM activities. Questions such as, “Which of the activities listed below have you participated in in the past year? (You can choose more than one)” were included.

The students’ engagement in these activities was then evaluated with respect to the “degree of engagement” as follows: No STEM engagement, low level of STEM engagement (visits to science centers/museums/zoos), moderate level of STEM engagement (specialized group visited their class/ after school STEM club), and high STEM engagement (involved in a STEM program/competition/fair). This is based on the work by Franz-Odendaal et al. (2016).
All of these are factors that potentially influence student interest in STEM fields, and the data was collected to attempt to understand the effect of these factors on students’ interest.

In addition, an open-ended question was asked: “Are you interested in a STEM (Science, Technology, Engineering and Mathematics) career? Why or why not?” This shed light into the answers of some questions such as, “I am interested in careers that involve engineering.” This is also based on the work of Franz-Odendaal et al. (2016), and following recommendations by Sahin et al. (2015). The full survey of 57 questions is shown in Appendix C.

In addition to the pre-survey, each day, students were asked to write a journal about their experience that day, and their response was invited through the journal prompt shown in Appendix E. This included questions about what they learned that day, and whether their perception of STEM changed after the day’s activities. This journal is based on the work of Mohr-Schroeder et al. (2014).

Each day of the camp, quotes were extracted from the journals, as well as choosing some photos/videos taken during that day. The journal quotes and photos/videos were uploaded to the parent blog. A short summary of the day’s activities was also added to the blog. A daily reminder was sent to the parents to access the blog, and see what their child had done that day. This helped parents understand the camp, and assisted them as they completed the post-survey. At the end of the engineering camp, students completed the post-camp survey. This survey was the same as the pre-survey, but it included satisfaction questions about the camp itself.
Data Analysis

The analysis of the quantitative and qualitative data for this mixed method research study was performed concurrently, once all data had been collected from the students and parents.

Quantitative data. The quantitative data was analyzed via a statistical package (SPSS), looking for changes in significance between the pre and post-surveys for both parents’ perceptions and students’ interest, as well as differences per gender. The total number of students was N= 33.

A significance test (Two tailed Students’ T-Test) was conducted for the entire pool of students, and another T-Test was conducted on the students who started below average on interest in STEM, to see if the low interest students had larger gains than the entire group. The cutoff point was 3 and lower on the 5 point Likert scale, as 3 is neutral, and 2 is disagree, and 1 is strongly disagree. This is based on the work of Hernandez et al. (2014). Additionally, since participation in the camp is voluntary, it was expected that participants would come to the camp with interest in science, as observed by Aschbacher et al. (2014). An examination of the students that came with low interest in science gave a more accurate indication of the success of the camp in improving interest in STEM.

Correlation between various factors and the students’ interest, was also analyzed. Those factors include parents’ perceptions, parents’ education, parents’ occupation and income, students’ STEM engagement, gender, and peer effects. The correlation was calculated using Pearson’s correlation.

Finally, the sample participating in the study, may not be representative of the population of Utah. This means that inference statistics may not be appropriate to use,
and a more appropriate way to present the data is through descriptive statistics, using the mean, median, standard deviation and bar charts. Those descriptive statistics show trends in the data without drawing inferences from the sample to the population. This was recommended by a statistician at USU, and shown in the work of Hayter (2012).

Additional statistical calculations were done with an online calculator, developed by Arizona State University by Soper (2017), based on the textbook Statistical Power Analysis for the Behavioral Sciences by Cohen (1988). This calculator was used due to its simplicity of use, in addition to giving accurate results without having to do statistical calculations by hand.

Qualitative data. Qualitative data was analyzed from both students and parents, using a qualitative analysis software (MaxQDA). MaxQDA is an analysis software used for coding qualitative data, and to calculate interrater reliability. It was chosen due to its user-friendly interface, the researcher and the other coder’s familiarity with it, as well as being the recommended coding software, by the instructor who taught the course “Qualitative Methods in Engineering Education” at USU. Coding followed recommendations from the literature. Specifically, the Coding Manual for Qualitative Researchers by Saldana (2016), as well as the Qualitative Inquiry and Research Design book by Creswell (2012). Creswell’s book suggests that the analysis of qualitative data, “involves organizing the data, conducting a preliminary read-through of the database, coding and organizing themes, representing the data, and forming an interpretation of them.” (p. 179). The coding approach, is detailed in the following section.

To ensure inter-rater reliability for the qualitative data, the data was coded by more than one person; the researcher and a qualified graduate student. The coding
analysts have an understanding of qualitative research, and the software that was used for the analysis (MaxQDA), as well as having experience in coding through their coursework as Ph.D. students, as well as their research. Each of the coders have a Master’s degree, one in Mechanical Engineering and one in Computer Science. Additionally, both coders were in their last year as Ph.D. students in Engineering Education.

After performing preliminary readings of the data, the coders started developing a coding table. In the first phase of analysis, the coding table emerged with the four main themes the coders agreed on. The coding table was expanded during the second phase of coding to include the subthemes the coders agreed on at the end of the first phase of coding. The exact procedures followed are detailed in the section below. The coding table is shown below, and in Chapter 4.
Table 8

Coding Table

<table>
<thead>
<tr>
<th>Coding Phase</th>
<th>Coding stage</th>
<th>Description/Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Attribute Coding</td>
<td>Demographics</td>
</tr>
<tr>
<td>Phase 1</td>
<td>Structural Coding</td>
<td>1. Learning new STEM content at the camp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Factors influencing interest in STEM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Changes in perception about STEM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Parent Perceptions about STEM</td>
</tr>
<tr>
<td>Phase 2</td>
<td>Descriptive coding</td>
<td>1.1 Incidental Learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 Fish Tagging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3 Measuring Water properties</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.4 Building a water filter and water Treatment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 Water Cycle and Watersheds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.1 Money, Future Career, and Applicability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2 Hobbies, personal interests, having fun, grades and abilities,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 Nature, animals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.4 School, STEM camps and activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5 Family and Extended, Friends, Teachers, influential</td>
</tr>
<tr>
<td></td>
<td></td>
<td>people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.1 Learning what STEM professionals can do</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2 Learning activities changed perception/interest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.3 Learning a lot in the camp reinforced/changed the choice to go</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.4 No change</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.5 I don’t know</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.1 STEM are growing job fields</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.2 Gives the child the knowledge to choose a career</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.3 STEM is a huge part of life</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.4 STEM provides more career opportunities</td>
</tr>
</tbody>
</table>

**Coding Approach.** Coding of the data, followed the two phases of coding, outlined by Saldana (2016). Coding was conducted by two coders. After carrying out the first phase of coding, the codes were combined, and checked for inter-coder reliability,
and Cronbach’s Alpha was calculated between the coders. The accepted level should be at least 0.8 (Creswell, 2012). The coders arbitrated to arrive at a consensus of at least 80% inter-rater reliability. The same process was repeated with the second phase of coding. The results from coding the qualitative data, were then interpreted in conjunction with those from the quantitative portion. This was completed according to recommendations from the literature about mixed methods research, such as Creswell’s book, Designing and Conducting Mixed Methods Research (2010).

The first phase started with attribute coding, which provided information such as participant demographics. The second step in the first phase was to choose between holistic and structural coding. Structural coding was used as it was suitable for multiple participants, for open-ended survey questions and transcripts, and for use when specific research questions are presented (Saldana, 2016). Structural coding is widely considered to be appropriate for just about any kind of qualitative study. This method is based on finding codes based on the content of the data, and is used to initially categorize the data, and to identify large segments of text, which can then form the basis of a deeper analysis (Saldana, 2016).

Both coders read the data, and came up with broad/general themes in the data. The two coders met to discuss the themes they found, and after some discussion, they arrived at four main themes or codes. Example themes were; “Factors influencing interest in STEM” and “Parent Perceptions about STEM”.

Example phrases from participants for the first theme included; “I am interested in the engineering part of the stem career because I want to learn how to create things that will help others” and “I think that most careers in STEM are big money earners.”
Sample phrases from participants for the second theme included; “STEM subjects are a huge part of our lives. I want my child to be successful in a career and I see that happening if he pursues a STEM career;” and “I believe that the demand for workers in STEM careers will continue to increase as we continue to advance as a society. My daughter has a talent for science and math, and if she decides to pursue a STEM career, I foresee her having many opportunities in her future. I am glad that the STEM industry today (as a whole) really seems to encourage females in these fields.”

After finishing the first phase of coding, structural coding, the coders met to discuss the codes they disagreed on. The interrater reliability (kappa) before arbitration ranged between $k = 0.18 - 0.37$ for the four files used in the coding process; parents’ perceptions survey, students’ pre-survey, students’ post-survey and students’ reflections and feedback. After the arbitration, the interrater reliability ranged between $k = 0.93 \text{–} 0.99$.

Additionally, as the two coders worked on the first phase of coding, they also looked for sub-codes that fell under the four main themes. Similar to the first phase of coding, the coders met to discuss the sub-codes they came up with, and after some discussion, they arrived at a consensus for the sub-codes that were used for the second phase of coding. Those sub-codes or sub-categories ranged from 3-5 per main theme. Both main themes/codes and sub-codes are shown in Table 8.

The second phase of coding used descriptive coding, which essentially looks for nouns and phrases that describe the topic (Saldana, 2016). Similar to structural coding, descriptive coding is flexible, and can be used for just about any form of qualitative analysis, and is especially good for beginner qualitative researchers. Additionally,
descriptive coding is essential for second phase coding, and for further analysis and interpretation (Saldana, 2016)

Sub-codes under the main codes discussed above included the sub-codes, “Money, Future Career, and Applicability” and “Hobbies, personal interests, having fun, grades and abilities,” included under the main theme, “Factors influencing interest in STEM Career”.

Example phrases from participants for the first sub-code include; “I am interested in a STEM career because I think it is challenging and it helps me and encourages me to try harder in school. I am interested in Biomedical Engineering, so I will have to try hard in STEM fields at school” and “Yes, I think these specific careers are the best. There are so many to choose from, so many things to do, and you can even come up with something and adjust what it is to fit your interest.”

Sample phrases from participants for the second theme include; “Ya, I enjoy STEM and I have a lot of fun with these types of things,” and “Yes, because I like to know how things work and make and test things.”

Similar to the first phase of coding, the coders met to discuss codes they disagreed on. The interrater reliability before arbitration ranged between k = 0.02 – 0.08 for the four files used in the coding process. After the arbitration, the interrater reliability ranged between k = 0.79 - 0.99 with an average interrater reliability for the entire data set of k = 0.85.

After the coding was completed, the data was analyzed through counting the instances that some codes appeared, which is referred to as magnitude coding. Namey, Guest, Thairu, & Johnson (2008) recommend that code frequency should be determined
based on the number of participants who mention a certain theme rather than the total number of times a theme appears in the data.

Magnitude coding adds a supplemental numeric to codes to indicate intensity, frequency or presence (Saldana, 2016). Magnitude coding is appropriate for descriptive qualitative data in education, and the social sciences that also use quantitative methods as evidence of outcomes (Saldana, 2016). This was recommended by Saldana (2016) as a way to “quantisify” qualitative data in mixed methods studies, and is a method that is gaining validity in qualitative inquiry. “Sometimes words say it best; sometimes numbers do; and sometimes both work in concert to compose a richer answer, and corroborate each other.” (Saldana, 2016, p. 87).

Additionally, a narrative was written by the researcher that describes the students’ and their parents’ perception about STEM fields. The narrative was written according to the recommendations from books about Qualitative data analysis, such as the books by Creswell (2012) and Saldana (2016). Finally, the qualitative data was also discussed in conjunction with the quantitative data to offer a mixed analysis perspective into the results.

**Summary**

This research is a concurrent mixed methods study to explore the effectiveness of a summer engineering camp on the interest of students to go into STEM fields, as well as their parents’ perception about STEM fields. The study also explored the factors influencing students’ interest in STEM.
Data was collected through the use of surveys before and after the camp, for both students and their parents. Students also completed daily journals about their experience in the camp.

The quantitative data was analyzed through inference and descriptive statistics. The qualitative data was coded and analyzed according to recommendations from the literature. The two sources of data were discussed together to answer the research questions.
Chapter IV

Results

The purpose of this study was to examine the effect of attending a one-week engineering summer camp on middle school students’ interest to pursue a career in STEM fields. Additionally, the study aimed at finding the major influences that are associated with the students’ interest. Finally, the study looked at the effect of a summer engineering camp on parents’ perception of STEM fields.

The study pursued the following objectives:

1. Determine if there is a significant difference between students’ interest in STEM field before and after attending a week-long engineering summer camp with a special focus on students who started the camp with low interest.

2. Determine which factors, if any, are correlated with students’ interest in STEM fields. Those factors include gender, ethnicity, STEM involvement, socio-economic status and education of parents, parents’ perception of STEM fields and peer attitudes towards STEM fields.

3. Determine if parents’ perceptions of STEM are affected by their child attending a one week summer camp.

Research Questions

The study was guided by the following research questions:

1. Does a summer engineering camp experience affect the perceived level of interest of secondary school students in STEM fields, especially those who enter the camp with a low perceived interest level? And how does it affect their interest?

2. What factors influence students’ interest, or lack of interest, to pursue a career in STEM fields?
3. How does a summer engineering camp experience attended by their child affect parents’ perception of STEM fields?

In this chapter, the results from both the quantitative and qualitative data of this research will be presented.

Participants

The number of students participating in this research was 36 students in the pre-survey. However, three of those students dropped out midway through the camp due to various reasons. This left 33 students who completed the post survey. There were 38 parents who participated in the pre survey, and 24 parents who participated in the post survey. Participant demographics for both student participants and their parents is shown in Tables 9 and 10 below.

Table 9

Demographics of student participants

<table>
<thead>
<tr>
<th>Category</th>
<th>Number (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age in years N (%)</strong></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>2 (5.5%)</td>
</tr>
<tr>
<td>14</td>
<td>33 (91.7%)</td>
</tr>
<tr>
<td>15</td>
<td>1 (2.7%)</td>
</tr>
<tr>
<td><strong>Gender N (%)</strong></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15 (41.6%)</td>
</tr>
<tr>
<td>Female</td>
<td>21 (58.3%)</td>
</tr>
<tr>
<td><strong>Ethnicity N (%)</strong></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>28 (77.7%)</td>
</tr>
<tr>
<td>Asian</td>
<td>3 (8.3%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>4 (11.1%)</td>
</tr>
<tr>
<td>American Indian or Native Alaskan</td>
<td>1 (2.7%)</td>
</tr>
</tbody>
</table>
As to be expected, most of the students are the same age at 14 years old. Most of the student participants are also from the White ethnicity (77.7%). This aligns with the U.S. Census data for Utah from 2016 in which there is 78.8% White ethnicity living in Utah. Hispanic students made 11.1% of the sample which also aligns with Census data from 2016 with 13.8% of the population of Utah being Hispanic. Asians and Native Americans also made up 8.3% and 2.7% of the population compared to the Census data of 2.5% and 1.0% respectively.

The nature of this research has students volunteering to participate which explains their high initial interest in STEM (Aschbacher et al., 2014). Additionally, the GEAR UP program targets students from low-income families. Those two factors indicate that the sample is not random or representative of the total population of Utah or the United States of America. Thus, the data cannot be generalized to the population of Utah, and thus inference statistics will only explain the differences between pre and post camp data, but will not be used to draw inferences about the population (Hayter, 2012).
Mothers made up almost 70% of the responses to the parent surveys. This is to be expected and similar to findings by (Harackiewicz, Rozek, Hulleman and Hyde, 2012).

Similar to Census data, 97.8% of the sample of parents had a high school degree or higher compared to 91.2% in the Census data. The average yearly income for the parent participants was approximately $57,000, which is slightly lower than the Census data of $60,727.
Quantitative Data

Quantitative data was collected from the students and their parents via pre and post camp surveys. Results from the quantitative data is presented as inference and descriptive statistics between the pre and post data, and correlation analysis.

Inference and Descriptive Statistics. This section presents the data from both students and parents in the form of inference and descriptive statistics between the pre and post surveys. Inference statistics examine whether there is a significant different between two sets of data, and in this research the Student’s T-Test was used. The P-value target was any amount less than 0.05, which shows a significant difference between two sets of data. Descriptive statistics represent the data by showing mean scores, standard deviation and we present the data in graphical form through bar charts.

The total number of students that participated in the study was 33, while the parents participating in the pre survey was 38 and the post survey was 24.

Science Interest. Science is the “S” in STEM. The following is the analysis of the students’ interest in Science.
Table 11

*Inference and Descriptive Statistics related to students’ Science career interest, and questions where there is a significant difference have their P-value in bold font.*

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Pre</th>
<th>Mean Post</th>
<th>Standard Deviation</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to use science in my future career</td>
<td>3.94</td>
<td>4.18</td>
<td>0.67</td>
<td>0.0440</td>
</tr>
<tr>
<td>If I do well in science classes, it will help me in my future career</td>
<td>4.09</td>
<td>4.21</td>
<td>0.97</td>
<td>0.4740</td>
</tr>
<tr>
<td>My parents would like it if I choose a science career</td>
<td>3.31</td>
<td>3.52</td>
<td>0.55</td>
<td>0.0320</td>
</tr>
<tr>
<td>I am interested in careers that use science</td>
<td>3.78</td>
<td>4.00</td>
<td>0.98</td>
<td>0.1610</td>
</tr>
<tr>
<td>Science interest average</td>
<td>3.96</td>
<td>4.11</td>
<td>0.37</td>
<td>0.0170</td>
</tr>
</tbody>
</table>

As can be seen in Table 11 above, there was a significant change in students’ interest and perception of science careers. There is an upward trend in the students’ interest, and this is clear when looking at the average of all the questions under Science, where the p-value was significant (0.017) despite the small number of students.

Additionally, the questions, “I plan to use science in my future career” and “My parents would like it if I choose a science career” both had a significant change with P-values of 0.044 and 0.032 respectively. It is worth noting that the question “I am interested in careers that use science” has a P-value of 0.16.

To show trends in a clear and concise fashion, descriptive statistics using bar charts are used for each question. Figure 6 below shows a bar plot of select questions under the *Science Perception* section of the survey. The questions were selected based on the purpose of the camp, which is to increase students’ interest in STEM careers, as well as which questions provided the data to answer the first research questions.
The values were changed from a 5-point Likert scale to a percentage to make the chart easier to read. The chart shows an upward trend from pre to post when it comes to students’ perception of Science as a field.

![Science Perception Chart]

*Figure 6. Students Perception of Science Pre and Post Camp*

**Mathematics Interest.** The following is the analysis of the students’ interest in Mathematics.
Table 12

Inference and Descriptive Statistics related to students’ mathematics career interest, questions where there is a significant difference have their P-value in bold font.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Pre</th>
<th>Mean Post</th>
<th>Standard Deviation</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to use mathematics in my future career</td>
<td>3.97</td>
<td>4.27</td>
<td>0.59</td>
<td>0.0050</td>
</tr>
<tr>
<td>If I do well in mathematics classes, it will help me in my future career</td>
<td>4.15</td>
<td>4.33</td>
<td>0.64</td>
<td>0.1100</td>
</tr>
<tr>
<td>My parents would like it if I choose a mathematics career</td>
<td>3.41</td>
<td>3.49</td>
<td>0.85</td>
<td>0.5400</td>
</tr>
<tr>
<td>I am interested in careers that use mathematics</td>
<td>3.69</td>
<td>4.12</td>
<td>0.75</td>
<td>0.0030</td>
</tr>
<tr>
<td>Mathematics interest average</td>
<td>3.89</td>
<td>4.03</td>
<td>0.40</td>
<td>0.0500</td>
</tr>
</tbody>
</table>

As can be seen in Table 12, there was a significant change in students’ interest and perception of mathematics careers. There is an upward trend in the students’ interest when looking at the average of all the questions under Mathematics. The p-value shows significance at 0.05 despite the small number of students. Additionally, the questions, “I plan to use mathematics in my future career” and “I am interested in careers that use mathematics” both had a significant change with P-values of 0.005 and 0.003 respectively. It is worth noting that the question, “If I do well in mathematics classes, it will help me in my future career” has a P-value of 0.11.

To show Mathematics trends more clearly, bar charts are used for each question. Figure 7 below shows a bar plot of select questions under the Mathematics section of the survey. The values were changed from a Likert scale to a percentage to make the chart easier to read. The chart shows an upward trend from pre to post when it comes to students’ perception of Mathematics as a field.
Figure 7. Students Perception of Mathematics Pre and Post Camp

**Technology Interest.** The following is the analysis of the students’ interest in Technology.

Table 13

*Inference and Descriptive Statistics related to students’ technology career interest,*

*questions where there is a significant difference have their P-value in bold font.*

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Pre</th>
<th>Mean Post</th>
<th>Standard Deviation</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to use technology in my future career</td>
<td>4.09</td>
<td>4.18</td>
<td>0.69</td>
<td>0.4470</td>
</tr>
<tr>
<td>If I learn a lot about technology, I will be able to do lots of different types of careers</td>
<td>4.31</td>
<td>4.45</td>
<td>0.52</td>
<td>0.0960</td>
</tr>
<tr>
<td>I am interested in careers that use technology</td>
<td>3.91</td>
<td>4.24</td>
<td>0.79</td>
<td>0.0190</td>
</tr>
<tr>
<td>Technology interest average</td>
<td>4.00</td>
<td>4.11</td>
<td>0.40</td>
<td>0.1230</td>
</tr>
</tbody>
</table>

As can be seen in Table 13, Technology has only one question where there was a significant change in students’ interest and perception. There is an upward trend in the
students’ interest when looking at the means of all the questions under Technology. Additionally, the question, “*I plan to use technology in my future career*” had a significant change with a P-value of 0.019. It is worth noting that the question, “*If I learn a lot about technology, I will be able to do lots of different types of careers.*” has a P-value of 0.096.

To show Technology trends more clearly, bar charts are used for each question. Figure 8 below shows a bar plot of select questions under the Technology section of the survey. The values were changed from a Likert scale to a percentage to make the chart easier to read. This chart shows an upward trend from pre to post when it comes to students’ perception of Technology as a field.

*Figure 8. Students Perception of Technology Pre and Post Camp*
**Engineering Interest.** The following is the analysis of the students’ interest in Engineering.

Table 14

*Inference and Descriptive Statistics related to students’ perception of Engineering, questions where there is a significant difference have their P-value in bold font.*

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Pre</th>
<th>Mean Post</th>
<th>Standard Deviation</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to use engineering in my future career</td>
<td>3.72</td>
<td>4.06</td>
<td>0.90</td>
<td>0.0390</td>
</tr>
<tr>
<td>If I learn a lot about engineering, I will be able to do a lot of different types of careers</td>
<td>4.09</td>
<td>4.3</td>
<td>0.61</td>
<td>0.0510</td>
</tr>
<tr>
<td>My parents would like it if I choose an engineering career</td>
<td>3.47</td>
<td>3.51</td>
<td>0.91</td>
<td>0.7010</td>
</tr>
<tr>
<td>I am interested in careers that involve engineering</td>
<td>3.94</td>
<td>4.12</td>
<td>0.64</td>
<td>0.1100</td>
</tr>
<tr>
<td>I would feel comfortable talking to people who are engineers</td>
<td>3.59</td>
<td>3.97</td>
<td>0.71</td>
<td>0.0050</td>
</tr>
<tr>
<td>Engineering interest average</td>
<td>3.83</td>
<td>4.03</td>
<td>0.42</td>
<td>0.0110</td>
</tr>
</tbody>
</table>

As can be seen in Table 14, there was a significant change in students’ interest and perception of engineering careers. There is an upward trend in the students’ interest when looking at the average of all the questions under Engineering where the p-value was a significant 0.011 despite the small number of students. Additionally, the questions, “I plan to use engineering in my future career” and “I would feel comfortable talking to people who are engineers” both had a significant change with P-values of 0.039 and 0.005 respectively. Interestingly, the question, “I would feel comfortable talking to people who are engineers” experienced a very significant increase. Since, most of the people delivering the camp were engineers, this shows the students’ perception of engineers improved significantly.
It is worth noting that the question “If I learn a lot about engineering, I will be able to do a lot of different types of careers” and “I am interested in careers that involve engineering” has P-values of 0.051 and 0.110 respectively.

To show trends more clearly, bar charts are used for each question. Figure 9 shows a bar plot of select questions under the Engineering section of the survey. The values were changed from a Likert scale to a percentage to make the chart easier to read. This chart shows an upward trend from pre to post when it comes to students’ perception of Engineering as a field.

![Engineering Perception Chart]

**Figure 9. Students Perception of Engineering Pre and Post Camp**

**STEM Interest.** The following is the analysis of the students’ interest in STEM in general, and it was obtained by averaging the questions related to student career interest in those fields. For example the question, “I plan to use STEM in my future career” was obtained by taking the average of the questions, “I plan to use Science in my
future career”, “I plan to use Mathematics in my future career”, “I plan to use Technology in my future career” and “I plan to use Engineering in my future career”.

Table 15

Inference and Descriptive Statistics related to students’ perception of STEM, questions where there is a significant difference have their P-value in bold font.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to use STEM in my future career</td>
<td>3.93</td>
<td>0.54</td>
<td>0.0140</td>
</tr>
<tr>
<td>I am interested in careers that involve STEM</td>
<td>3.82</td>
<td>0.53</td>
<td>0.0030</td>
</tr>
<tr>
<td>STEM interest average</td>
<td>3.92</td>
<td>0.31</td>
<td>0.0080</td>
</tr>
</tbody>
</table>

As can be seen in Table 15, there was a significant change in students’ interest and perception of STEM careers on average. There is an upward trend in the students’ interest when looking at the average of all 44 questions under STEM, where the p-value was a significant 0.008, despite the small number of students. Additionally, the questions, “I plan to use STEM in my future career” and “I am interested in careers that involve STEM” both had a significant change with P-values of 0.014 and 0.008 respectively.

To show trends more clearly, bar charts for each question are shown. Figure 10 shows a bar plot of averaged questions related to STEM careers in the survey. The values were changed from a Likert scale to a percentage to make the chart easier to read. This chart shows an upward trend from pre to post when it comes to students’ perception of STEM careers and as a field.
The following section discusses a sub group of the same participants which includes students who started the camp with low interest levels of 3 or less on the Likert scale, which is neutral or less. Those students also ended the camp with an increased interest level of 4 or 5 on the Likert scale, which reflect answers of Agree and Strongly Agree respectively.

**STEM interest for the sub group that started with low interest.** For this section, one table is used to show the interest change in careers in all four of STEM fields studied in this research.
Inference and Descriptive Statistics related to students’ STEM career interest, and questions where there is a significant difference have their P-value in bold font.

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Pre</th>
<th>Mean Post</th>
<th>Standard Deviation</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to use science in my future career</td>
<td>3.00</td>
<td>4.14</td>
<td>0.37</td>
<td><strong>0.000</strong></td>
</tr>
<tr>
<td>I am interested in careers that use science</td>
<td>3.00</td>
<td>4.33</td>
<td>0.52</td>
<td><strong>0.001</strong></td>
</tr>
<tr>
<td>I plan to use mathematics in my future career</td>
<td>2.80</td>
<td>4.00</td>
<td>0.45</td>
<td><strong>0.004</strong></td>
</tr>
<tr>
<td>I am interested in careers that use mathematics</td>
<td>2.57</td>
<td>4.00</td>
<td>0.79</td>
<td><strong>0.003</strong></td>
</tr>
<tr>
<td>I plan to use technology in my future career</td>
<td>3.00</td>
<td>4.33</td>
<td>0.57</td>
<td>0.057</td>
</tr>
<tr>
<td>I am interested in careers that use technology</td>
<td>2.60</td>
<td>4.20</td>
<td>0.89</td>
<td><strong>0.016</strong></td>
</tr>
<tr>
<td>I plan to use engineering in my future career</td>
<td>2.77</td>
<td>4.11</td>
<td>0.71</td>
<td><strong>0.000</strong></td>
</tr>
<tr>
<td>I am interested in careers that use engineering</td>
<td>3.00</td>
<td>4.44</td>
<td>0.55</td>
<td><strong>0.005</strong></td>
</tr>
</tbody>
</table>

As can be seen in Table 16, all but one question was significant. There is an upward and significant trend in the students with low interest in careers in STEM fields. The only question that was not significant is, “I plan to use technology in my future career” with a p-value of 0.057. The same question had a p-value of 0.4470 when looking at the full sample of students.

Additionally, the questions, “I am interested in careers that use science” and “I am interested in careers that use engineering” changed from having non-significant p-values of 0.161 and 0.11 respectively for the full sample, to having significant p-values when looking at the students starting with low interest where the p-values for those two questions became significant 0.001 and 0.000 respectively. This shows that the
intervention may have been more effective for the students who started with low interest in those fields.

The rest of the questions where significant in both the full sample and the sub-group. However, the p-values where generally smaller for the sub-group. This shows that the sub group that started with low interest had more gains in terms of increases in interest in STEM fields.

To show trends more clearly, bar charts are used to show each question. Figures 11 and 12 show bar plots of career-related questions for both the full sample, and the subgroup. The first Figure is for Science and Mathematics while the second Figure is for Technology and Engineering. The values were changed from a Likert scale to a percentage to make the chart easier to read. Those charts show the differences in gain for the full sample, versus the sub group that started with low interest. The sub group that started with low interest made much greater gains in interest compared to the rest of the group.
Figure 11. Students Perception of Science and Mathematics Pre and Post Camp for both the full sample and the sub group that started with low interest.

Figure 12. Students Perception of Technology and Engineering Pre and Post Camp for both the full sample and the sub group that started with low interest.
Male vs female interest in STEM. The following is the results of students’ interest in the various fields of STEM displayed by gender, as can be seen in Table 17.

Table 17

*Inference and Descriptive Statistics related to male vs female students’ STEM career interest and questions where there is a significant difference have their P-value in bold font.*

<table>
<thead>
<tr>
<th>Question</th>
<th>Mean Male Interest</th>
<th>Mean Female Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>I am interested in careers that involve science</td>
<td>3.92</td>
<td>4.00</td>
</tr>
<tr>
<td>I am interested in careers that involve mathematics</td>
<td>3.64</td>
<td>4.00</td>
</tr>
<tr>
<td>I am interested in careers that involve technology</td>
<td>4.07</td>
<td>4.20</td>
</tr>
<tr>
<td>I am interested in careers that involve engineering</td>
<td>4.00</td>
<td>4.07</td>
</tr>
<tr>
<td>I am interested in careers that involve STEM</td>
<td>3.91</td>
<td>4.07</td>
</tr>
</tbody>
</table>

As can be seen in Table 17, female students experienced a higher gain in interest between the pre and the post test. Females started the camp with lower interest than males in all the questions except mathematics. At the end of the camp, females had gained more interest in all the fields, and ended the camp with equal or higher interest than males, in all the fields. Significant increases in interest for females include mathematics, technology and STEM careers with P-values of 0.015, 0.024 and 0.019 respectively. The significance observed is even more impressive considering the small sample size of 18 female students. Males also had a small sample size of 15, and only one question proved significant between the pre and the post. This question is the average interest in all STEM fields with a P-value of 0.019.
To show trends more clearly, a bar chart is used to show the differences in gain for the males versus females. As can be seen in Figure 13 below, females show a greater interest gain in all the questions.

![Bar chart showing male vs female interest in STEM careers before and after the camp](image)

**Figure 13.** Students Perception of Science and Mathematics Pre and Post Camp for both males and females

**The effect of the camp on student choice of career.** The following is the results of what the students perceived to be the camp’s effect on their choice of career, as can be seen in Table 18.
Table 18

*Student answers to the survey question, “How did the camp affect your choice of career for the future?”*

<table>
<thead>
<tr>
<th>Question</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced my choice</td>
<td>21</td>
</tr>
<tr>
<td>Changed my choice to a STEM career</td>
<td>2</td>
</tr>
<tr>
<td>Changed my choice to a non-STEM career</td>
<td>0</td>
</tr>
<tr>
<td>No influence on my decision</td>
<td>8</td>
</tr>
<tr>
<td>Made me more confused</td>
<td>2</td>
</tr>
</tbody>
</table>

As can be seen in Table 18, only 2 students changed their career choice to a STEM field as a result of the camp, and no students changed their mind to go into a non-STEM field as a result of the camp. The majority said that the camp reinforced their choice of career, with 21 students picking that option. Out of the 21 students, 19 of them said they are interested in STEM careers, and that the camp reinforced their decision. The other two students were interested in other fields. Out of the 8 that said that the camp had no influence on their decision, 4 had decided on a STEM career, and the camp had no influence on that decision, while the other four had chosen non-STEM fields, and the camp had no influence on their decision. Finally, two students said that the camp made them more confused, and they did not answer the question as to what kind of career they are looking into.
**Parent Perceptions.** The following is the results of the parents’ surveys. Similar to students, parents completed surveys before and after the camp. Unlike students, not the same parents completed the pre and post surveys. As described in Chapter 3, parent surveys were sent in both electronic format via e-mail, as well as paper versions via mail, or sent with the students at the conclusion of the camp. The pre survey were completed by 38 parents while the post survey was completed by 24 parents.

Table 19

<table>
<thead>
<tr>
<th>Inference and Descriptive Statistics related to parents’ perception of STEM</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question</strong></td>
<td>Pre</td>
<td>Post</td>
<td></td>
</tr>
<tr>
<td>Parents’ math perception</td>
<td>4.61</td>
<td>4.83</td>
<td>0.64</td>
</tr>
<tr>
<td>Parents’ science perception</td>
<td>4.73</td>
<td>4.69</td>
<td>0.50</td>
</tr>
<tr>
<td>Parents’ math and science perception average</td>
<td>4.67</td>
<td>4.77</td>
<td>0.51</td>
</tr>
<tr>
<td>I believe engineering improves our quality of life</td>
<td>4.76</td>
<td>4.92</td>
<td>0.54</td>
</tr>
<tr>
<td>I want my child(ren) to pursue a career in engineering</td>
<td>4.15</td>
<td>4.42</td>
<td>0.83</td>
</tr>
<tr>
<td>I think it is equally important for both boys and girls to learn engineering</td>
<td>4.78</td>
<td>4.83</td>
<td>0.53</td>
</tr>
<tr>
<td>Parents’ engineering perception average</td>
<td>4.57</td>
<td>4.72</td>
<td>0.47</td>
</tr>
</tbody>
</table>

As can be seen in Table 19 above, none of the results from the parents’ surveys were significant. This can be attributed to two factors; the parents had very high perceptions of STEM fields, with most of these questions yielding parents’ answers averaging more than 4.5 on a 5-point scale. The other factor was the small sample size, especially in the post survey with less parents participating in the surveys. However, the
trends are positive, with most of the questions showing higher averages on the post survey than the pre survey.

Of particular interest for this research is the question, “I want my child(ren) to pursue a career in engineering” which experienced a change from 4.15 on the pre survey, to 4.42 on the post survey. While this change was not significant due to the small sample size, it is still the largest numerical change in the parents’ surveys.

While the parent survey asked about the occupation of the parents, that data was not used in the analysis, as it is hard to quantify, and to analyze as one of the factors influencing their children’s interest in STEM. Instead, the parents’ education, income and perception of STEM, were all factors that were used in the analysis.

To show trends more clearly, bar charts are used for each question. Figure 14 shows a bar plot of questions about parents’ perceptions about STEM. The values were changed from a Likert scale to a percentage to make the chart easier to read. This chart shows an upward trend from pre to post when it comes to parents’ perception of STEM.
Factors influencing student interest in STEM. This section shows the factors influencing student interest in the various fields in STEM. Correlations were calculated using SPSS software using Pearson’s correlation, and the interpretation was based on Cohen’s (1988) social sciences rule of thumb to identify strong and weak correlations. A correlation that is above 0.5 is considered strong, 0.3-0.5 is considered moderate, and 0.1-0.3 is considered a weak correlation. The factors used in the calculations are based on the students’ and parents’ responses to questions in the surveys. The responses to those questions were correlated with the students’ responses to the questions, “I am interested in careers that involve Science, Technology, Mathematics and Engineering”, and reported in the following tables. For example; the question, “I am able to get a good grade in my science class” is used as a factor that represents the student’s ability to get
good grades in science, but in Tables 20 through 24, it is presented as the column labeled ‘question’, without changing the wording and used as a factor.

The correlations coefficients are presented in a series of tables for both the pre and post surveys as well as for the four main fields under the STEM umbrella, and the average for all STEM fields.

Factors Influencing Science Interest. In this section, the correlation coefficients between science interest, and various factors, are presented in Table 20, followed by a discussion of the results.
Table 20

_Correlation coefficients between various factors and the career interest in Science_

<table>
<thead>
<tr>
<th>Factor</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am able to get a good grade in my science class</td>
<td>0.412</td>
<td>0.056</td>
</tr>
<tr>
<td>I will work hard in my science class</td>
<td>0.295</td>
<td>0.180</td>
</tr>
<tr>
<td>If I do well in science classes, it will help me in my future career</td>
<td>0.585</td>
<td>0.829</td>
</tr>
<tr>
<td>My parents would like it if I choose a science career</td>
<td>0.302</td>
<td>0.442</td>
</tr>
<tr>
<td>I like my science class</td>
<td>0.544</td>
<td>0.748</td>
</tr>
<tr>
<td>I have a role model in a science career.</td>
<td>0.475</td>
<td>0.104</td>
</tr>
<tr>
<td>Science Interest Average</td>
<td>0.767</td>
<td>0.739</td>
</tr>
<tr>
<td>I am able to get a good grade in my mathematics class</td>
<td>0.277</td>
<td>0.241</td>
</tr>
<tr>
<td>I am able to do well in activities that involve engineering.</td>
<td>0.589</td>
<td>0.660</td>
</tr>
<tr>
<td>STEM grades and activities</td>
<td>0.614</td>
<td>0.462</td>
</tr>
<tr>
<td>Overall interest in STEM</td>
<td>0.597</td>
<td>0.546</td>
</tr>
<tr>
<td>STEM camps attended</td>
<td>-0.071</td>
<td>0.166</td>
</tr>
<tr>
<td>Level of STEM engagement</td>
<td>0.220</td>
<td>0.233</td>
</tr>
<tr>
<td>First time participating in STEM-related activities</td>
<td>0.199</td>
<td>-0.143</td>
</tr>
<tr>
<td>Friends’ perception of science</td>
<td>0.181</td>
<td>0.497</td>
</tr>
<tr>
<td>Parents’ perception of math</td>
<td>0.350</td>
<td>0.200</td>
</tr>
<tr>
<td>Parents’ perception of science</td>
<td>0.354</td>
<td>0.401</td>
</tr>
<tr>
<td>Parents’ perception of engineering</td>
<td>-0.072</td>
<td>0.100</td>
</tr>
<tr>
<td>Parents’ Education</td>
<td>0.038</td>
<td>0.039</td>
</tr>
<tr>
<td>Parents’ Income</td>
<td>0.304</td>
<td>-0.362</td>
</tr>
</tbody>
</table>
As shown in Table 20, the strongest correlations with regards to interest in science careers is the students’ perception of science, their interest in science, and how much they like science, as well as their perceived ability of doing good in it. Some of the strongest correlations include, “If I do well in science classes, it will help me in my future career”, “I like my science class” and “the overall interest in science” were obtained by averaging the 11 questions about interest in science, with correlation coefficients of 0.829, 0.742 and 0.739 respectively. Interestingly, the factor, “STEM camps attended” increased from -0.071 to 0.166 (pre to the post survey). This may be due to the large number of students who had attended zero camps prior to the engineering camp they attended at USU in July.

The factor, “Friends’ perception of science” had a strong correlation, especially in the post camp, with a correlation coefficient of 0.497.

Interestingly enough, parental influence was weaker in comparison to other factors, with their perception of science, math and engineering having weak to moderate correlations post camp, with correlation coefficients of 0.401, 0.2 and 0.1 respectively. Parent education and income did not play a strong role, and had a weak correlation. However, students’ perception of how their parents would think of a science career had a moderate to strong correlation, with the factor, “My parents would like it if I choose a science career” having a post camp correlation coefficient of 0.442.

**Factors Influencing Mathematics Interest.** In this section, the correlation coefficients between mathematics interest and various factors are presented in Table 21 followed by a discussion of the results.
Table 21

*Correlation coefficients between various factors and the career interest in Mathematics*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am able to get a good grade in my mathematics class</td>
<td>0.623</td>
<td>0.494</td>
</tr>
<tr>
<td>I will work hard in my mathematics class</td>
<td>0.534</td>
<td>0.559</td>
</tr>
<tr>
<td>If I do well in mathematics classes, it will help me in my future career</td>
<td>0.717</td>
<td>0.913</td>
</tr>
<tr>
<td>My parents would like it if I choose a mathematics career</td>
<td>0.526</td>
<td>0.461</td>
</tr>
<tr>
<td>I like my mathematics class</td>
<td>0.516</td>
<td>0.472</td>
</tr>
<tr>
<td>I have a role model in a mathematics career.</td>
<td>-0.097</td>
<td>0.403</td>
</tr>
<tr>
<td>Math interest average</td>
<td>0.830</td>
<td>0.869</td>
</tr>
<tr>
<td>I am able to get a good grade in my science class</td>
<td>0.082</td>
<td>-0.035</td>
</tr>
<tr>
<td>I am able to do well in activities that involve engineering.</td>
<td>0.481</td>
<td>0.624</td>
</tr>
<tr>
<td>STEM grades and activities</td>
<td>0.578</td>
<td>0.456</td>
</tr>
<tr>
<td>Overall interest in STEM</td>
<td>0.741</td>
<td>0.751</td>
</tr>
<tr>
<td>STEM camps attended</td>
<td>0.188</td>
<td>0.133</td>
</tr>
<tr>
<td>Level of STEM engagement</td>
<td>-0.008</td>
<td>0.136</td>
</tr>
<tr>
<td>First time participating in STEM-related activities</td>
<td>0.217</td>
<td>0.256</td>
</tr>
<tr>
<td>Friends’ perception of science</td>
<td>0.397</td>
<td>0.532</td>
</tr>
<tr>
<td>Parents’ perception of math</td>
<td>0.219</td>
<td>0.033</td>
</tr>
<tr>
<td>Parents’ perception of science</td>
<td>-0.108</td>
<td>0.033</td>
</tr>
<tr>
<td>Parents’ perception of engineering</td>
<td>-0.002</td>
<td>-0.099</td>
</tr>
<tr>
<td>Parents’ Education</td>
<td>0.397</td>
<td>0.015</td>
</tr>
<tr>
<td>Parents’ Income</td>
<td>0.070</td>
<td>0.083</td>
</tr>
</tbody>
</table>
As shown in Table 21, the strongest correlations with regards to interest in mathematics careers include the students’ perception of mathematics, their interest in it, and how much they like it, as well as their perceived ability of doing good in it. Some of the strong correlations include, “I am able to get a good grade in my mathematics class”, “If I do well in math classes, it will help me in my future career”, “I like my math class”, and the overall interest in math, which was obtained by averaging the 11 questions about interest in math, with correlation coefficients of 0.494, 0.913, 0.472 and 0.869 respectively, the four of which are strong correlations. Friends’ perception of science had a strong correlation, especially in the post camp, with a correlation coefficient of 0.532.

Interestingly enough, parental influence was weaker in comparison to other factors, with their perception of science, math and engineering having weak post camp correlations with correlation coefficients of 0.033, 0.033 and -0.099 respectively. Parent education and income also did not play a strong role with weak correlations. However, students’ perception of how their parents would think of a mathematics career had a post camp moderate to strong correlation with the factor, “My parents would like it if I choose a mathematics career” having a correlation coefficient of 0.461. Similarly, role models in a mathematics career was a moderate correlation, with a correlation coefficient of 0.403.

Factors Influencing Technology Interest. In this section, the correlation coefficients between technology interest, and various factors, are presented in Table 22, followed by a discussion of the results.
Table 22

_Correlation coefficients between various factors and the career interest in Technology_

<table>
<thead>
<tr>
<th>Factor</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am able to do well in activities that involve technology.</td>
<td>0.269</td>
<td><em>0.608</em></td>
</tr>
<tr>
<td>I will learn about new technologies that will help me with school.</td>
<td><em>0.535</em></td>
<td><em>0.659</em></td>
</tr>
<tr>
<td>If I learn a lot about technology, I will be able to do lots of</td>
<td><em>0.486</em></td>
<td><em>0.805</em></td>
</tr>
<tr>
<td>different types of careers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like to use technology for class work.</td>
<td><em>0.595</em></td>
<td><em>0.563</em></td>
</tr>
<tr>
<td>I have a role model in a Technology career.</td>
<td>0.119</td>
<td>0.051</td>
</tr>
<tr>
<td>Technology interest average</td>
<td><em>0.754</em></td>
<td><em>0.867</em></td>
</tr>
<tr>
<td>I am able to get a good grade in my science class</td>
<td>-0.19</td>
<td>0.132</td>
</tr>
<tr>
<td>I am able to get a good grade in my mathematics class</td>
<td><em>0.406</em></td>
<td><em>0.458</em></td>
</tr>
<tr>
<td>I am able to do well in activities that involve engineering.</td>
<td>0.208</td>
<td><em>0.403</em></td>
</tr>
<tr>
<td>STEM grades and activities</td>
<td><em>0.353</em></td>
<td><em>0.642</em></td>
</tr>
<tr>
<td>Overall interest in STEM</td>
<td><em>0.520</em></td>
<td><em>0.647</em></td>
</tr>
<tr>
<td>STEM camps attended</td>
<td>0.331</td>
<td>0.242</td>
</tr>
<tr>
<td>Level of STEM engagement</td>
<td>0.173</td>
<td>0.171</td>
</tr>
<tr>
<td>First time participating in STEM-related activities</td>
<td>-0.097</td>
<td>0.159</td>
</tr>
<tr>
<td>Friends’ perception of science</td>
<td>-0.130</td>
<td>0.331</td>
</tr>
<tr>
<td>Parents’ perception of math</td>
<td>0.464</td>
<td>0.296</td>
</tr>
<tr>
<td>Parents’ perception of science</td>
<td>0.218</td>
<td><em>0.519</em></td>
</tr>
<tr>
<td>Parents’ perception of engineering</td>
<td>0.024</td>
<td>0.228</td>
</tr>
<tr>
<td>Parents’ Education</td>
<td>0.289</td>
<td>0.098</td>
</tr>
<tr>
<td>Parents’ Income</td>
<td>-0.246</td>
<td>-0.278</td>
</tr>
</tbody>
</table>
As shown in Table 22, the strongest correlations with regards to interest in technology careers includes the students’ perception of technology, their interest in it, and how much they like it, as well as their perceived ability of doing good in it. Some of the strongest correlations include, “I am able to do well in activities that involve technology”, “If I learn a lot about technology, I will be able to do lots of different types of careers”, “I like to use technology for class work”, and the overall interest in technology which was obtained by averaging the 11 questions about interest in technology, with correlation coefficients of 0.608, 0.805, 0.563 and 0.0867 respectively. Friends’ perception of science had a moderate correlation in the post camp with a correlation coefficient of 0.331.

Parental influence was somewhat weaker in comparison to other factors, with their perception of science, math and engineering having post camp moderate to strong correlations, with correlation coefficients of 0.519, 0.296 and 0.228 respectively. Parent education and income did not play a strong role, with weak correlations. Interestingly, role models in a technology career showed a weak post camp correlation, with a correlation coefficient of 0.051.

**Factors Influencing Engineering Interest.** In this section, the correlation coefficients between engineering interest and various factors are presented in Table 23, followed by a discussion of the results.
Table 23

*Correlation coefficients between various factors and the career interest in Engineering*

<table>
<thead>
<tr>
<th>Factor</th>
<th>I am interested in careers that involve engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
</tr>
<tr>
<td>I am able to do well in activities that involve engineering.</td>
<td>0.533</td>
</tr>
<tr>
<td>I will work hard on activities at school that involve engineering.</td>
<td>0.599</td>
</tr>
<tr>
<td>If I learn a lot about engineering, I will be able to do lots of different types of careers.</td>
<td>0.748</td>
</tr>
<tr>
<td>My parents would like it if I choose an engineering career</td>
<td>0.122</td>
</tr>
<tr>
<td>I like activities that involve engineering.</td>
<td>0.687</td>
</tr>
<tr>
<td>I have a role model in an engineering career.</td>
<td>-0.095</td>
</tr>
<tr>
<td>I am able to get a good grade in my science class</td>
<td>-0.064</td>
</tr>
<tr>
<td>I am able to get a good grade in my mathematics class</td>
<td>0.525</td>
</tr>
<tr>
<td>Engineering Interest Average</td>
<td>0.729</td>
</tr>
<tr>
<td>STEM grades and activities</td>
<td>0.464</td>
</tr>
<tr>
<td>Overall interest in STEM</td>
<td>0.611</td>
</tr>
<tr>
<td>STEM camps attended</td>
<td>0.187</td>
</tr>
<tr>
<td>Level of STEM engagement</td>
<td>0.036</td>
</tr>
<tr>
<td>First time participating in STEM-related activities</td>
<td>-0.165</td>
</tr>
<tr>
<td>Friends’ perception of science</td>
<td>0.249</td>
</tr>
<tr>
<td>Parents’ perception of math</td>
<td>0.254</td>
</tr>
<tr>
<td>Parents’ perception of science</td>
<td>0.106</td>
</tr>
<tr>
<td>Parents’ perception of engineering</td>
<td>-0.141</td>
</tr>
<tr>
<td>Parents’ Education</td>
<td>0.362</td>
</tr>
<tr>
<td>Parents’ Income</td>
<td>0.134</td>
</tr>
</tbody>
</table>
As shown in Table 23, the strongest correlations with regards to interest in engineering careers is the students’ perception of engineering, their interest in it, and how much they like it, as well as their perceived ability of doing good in it. Some of the strongest correlations include, “I am able to do well in activities that involve engineering.”, “If I learn a lot about engineering, I will be able to do lots of different types of careers.”, “I like activities that involve engineering,” and the overall interest in engineering, which was obtained by averaging the 11 questions about interest in engineering with correlation coefficients of 0.572, 0.619, 0.531 and 0.653 respectively, all four having strong correlations.

Other interesting factors include the students’ ability to get good grades in their science and mathematics classes, which produced a range between weak and strong correlations. In the pre camp, science and math had correlation coefficients of -0.064 and 0.525 respectively, while in the post camp, 0.33 and 0.272 respectively.

Friends’ perception of science had a moderate to strong correlation, especially in the post camp, with a correlation coefficient of 0.441.

Additionally, parental influence was weaker in comparison to other factors, with their perception of science, math and engineering having post camp weak to moderate correlations, with correlation coefficients of 0.408, 0.185 and 0.006 respectively. Parent education and income did not play a strong role, with weak correlations. However, students’ perception of how their parents would think of an engineering career had a moderate post camp correlation, with the factor, “My parents would like it if I choose an engineering career” having a correlation coefficient of 0.353. Interestingly, role models
in an engineering career showed a negative moderate post camp correlation, with a correlation coefficient of -0.201.

*Factors Influencing STEM Interest.* In this section, the correlation coefficients between STEM career interest and various factors are presented in Table 24, followed by a discussion of the results.
Table 24

*Correlation coefficients between various factors and the career interest in STEM*

<table>
<thead>
<tr>
<th>Factor</th>
<th>I am interested in careers that involve STEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
</tr>
<tr>
<td>Working hard at STEM activities/classes</td>
<td>0.675</td>
</tr>
<tr>
<td>If I do well in STEM classes and activities, it will help me in my future career.</td>
<td>0.829</td>
</tr>
<tr>
<td>My parents would like it if I choose a STEM career.</td>
<td>0.603</td>
</tr>
<tr>
<td>I like activities that involve STEM</td>
<td>0.584</td>
</tr>
<tr>
<td>I have a role model in a STEM career.</td>
<td>0.114</td>
</tr>
<tr>
<td>I am able to get a good grade in my science class</td>
<td>0.140</td>
</tr>
<tr>
<td>I am able to get a good grade in my mathematics class</td>
<td>0.662</td>
</tr>
<tr>
<td>I am able to do well in activities that involve engineering.</td>
<td>0.630</td>
</tr>
<tr>
<td>STEM grades and activities</td>
<td>0.711</td>
</tr>
<tr>
<td>Overall interest in STEM</td>
<td>0.865</td>
</tr>
<tr>
<td>STEM camps attended</td>
<td>0.235</td>
</tr>
<tr>
<td>Level of STEM engagement</td>
<td>0.139</td>
</tr>
<tr>
<td>First time participating in STEM-related activities</td>
<td>0.071</td>
</tr>
<tr>
<td>Friends’ perception of science</td>
<td>0.258</td>
</tr>
<tr>
<td>Parents’ perception of math</td>
<td>0.454</td>
</tr>
<tr>
<td>Parents’ perception of science</td>
<td>0.178</td>
</tr>
<tr>
<td>Parents’ perception of engineering</td>
<td>-0.064</td>
</tr>
<tr>
<td>Parents’ Education</td>
<td>0.414</td>
</tr>
<tr>
<td>Parents’ Income</td>
<td>0.104</td>
</tr>
</tbody>
</table>
As shown in Table 24, the strongest correlations, with regards to interest in STEM careers, includes the students’ perception of STEM, their interest in it, and how much they like it as well as their perceived ability of doing good in it. Some of the strongest correlations include, “STEM grades and activities”, “If I do well in STEM classes and activities, it will help me in my future career.”, “I like activities that involve STEM”, and the overall interest in STEM which was obtained by averaging the 44 questions about interest in STEM with correlation coefficients of 0.615, 0.892, 0.714 and 0.823 respectively, the four of which are very strong correlations. Interestingly, the factor, “STEM camps attended” stayed at a consistent 0.23 moderate correlation, from -0.071 to 0.166, pre to the post survey. The question asking, how many similar camps have the students attended, was only asked in the pre-survey, and 23 out of 33 students said they had attended no similar camp before this one. Of the remaining 10, eight of them said they had attended 1-2 camps, and two of them said they had attended three or more camps.

Other interesting factors include the students’ ability to get good grades in their science and mathematics classes, and do well in engineering activities. Those factors produced a range between weak and strong correlations. In the post camp, science and math had correlation coefficients of 0.028 and 0.483 respectively, while engineering had a correlation coefficient of 0.760.

Friends’ perception of science had a strong correlation, especially in the post camp, with a correlation coefficient of 0.607.

Interestingly enough, parental influence was weaker in comparison to other factors, with their perception of science, math and engineering having weak to moderate post camp correlations, with correlation coefficients of 0.203, 0.383 and 0.052 respectively. Parent education and income did not play a strong role, with very weak
correlations. However, students’ perception of how their parents would think of a STEM career, had a strong post camp correlation with the factor, “My parents would like it if I choose a STEM career” having a correlation coefficient of 0.529.

**Students’ Rating of the Various Camp Activities.** In this section, the students’ rating of the various activities in camp is presented in Table 25 below.

Table 25

*Students’ rating of the various camp activities*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Rating out of 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water cycle experiment (Rolling the dice, collecting beads)</td>
<td>84.8%</td>
</tr>
<tr>
<td>Fish tagging experiment</td>
<td>77.0%</td>
</tr>
<tr>
<td>River/watershed experiences with multiple data collection locations</td>
<td>88.5%</td>
</tr>
<tr>
<td>Rain water run off experiment.</td>
<td>81.8%</td>
</tr>
<tr>
<td>Storm water impacts, multiple locations.</td>
<td>86.1%</td>
</tr>
<tr>
<td>Sand filters</td>
<td>93.9%</td>
</tr>
<tr>
<td>In lab looking at bacteria under the microscope</td>
<td>87.9%</td>
</tr>
<tr>
<td>Logan Lagoon site visit</td>
<td>77.0%</td>
</tr>
<tr>
<td>Hyrum waste water treatment plant visit</td>
<td>77.6%</td>
</tr>
<tr>
<td>Poster Session</td>
<td>84.2%</td>
</tr>
</tbody>
</table>

As can be seen in Table 25 above, the students rated the “Sand Filters” activity as their favorite with a rating of 93.9%, while the visit to both waste water treatment plants, and the “fish tagging experiment” were rated lowest at about 77% each. The sand filters activity was the most hands-on activity in the camp, where each group built a sand filter,
and then proceeded to filter the water, and then measure the turbidity of the resulting filtered water. There was also an element of competition to see which group of students could build the best filter in terms of water clarity, and the time it takes to filter water. Burguillo (2009) found that the use of friendly competitions provides a strong motivation for students; helping to increase their performance. Similarly, Wirt (2011) found that students being engaged in science competitions increased their interest and engagement in STEM.

Conversely, the visits to the waste water treatment plants were mostly passive and the students followed an employee at those plants as they gave them a tour of those plants.

Similarly, the activities, “River/watershed experiences with multiple data collection locations”, “Storm water impacts, multiple locations” and “In lab looking at bacteria under the microscope” all had ratings in the high 80’s. Those were also heavily hands on activities.

Figure 15 below shows the students’ rating of the various camp activities.
This section will focus on the results of the qualitative coding process. As was explained earlier, four major themes emerged during coding. Sub themes have also emerged, and those are discussed as part of the main theme under which they fall. The coding table is shown again below for reference, with an added column showing the frequency of each code. During the analysis phase, the codes were looked at individually, and were not given weights based on insightfulness or value of comments, as that would be difficult to quantify, and is very subjective.
Table 26

**Coding Table with coding stage, themes and code frequencies**

<table>
<thead>
<tr>
<th>Coding Phase</th>
<th>Coding stage</th>
<th>Description/Themes</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>Attribute Coding</td>
<td>Demographics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Structural Coding</td>
<td>1. Learning new STEM content at the camp</td>
<td>342</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Factors influencing interest in STEM</td>
<td>281</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Changes in perception about STEM</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Parent Perceptions about STEM</td>
<td>30</td>
</tr>
<tr>
<td>Phase 2</td>
<td>Descriptive coding</td>
<td>1.1 Incidental Learning</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 Fish Tagging</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.3 Measuring Water properties</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.4 Building a water filter and water Treatment</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5 Water Cycle and Watersheds</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.1 Money, Future Career, and Applicability</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2 Hobbies, personal interests, having fun, grades and abilities,</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 Nature, animals</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.4 School, STEM camps and activities</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5 Family and Extended, Friends, Teachers, influential people</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.1 Learning what STEM professionals can do</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2 Learning activities changed perception/interest</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.3 Learning a lot in the camp reinforced/changed the choice to go into STEM career</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.4 No change</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.5 I don’t know</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.1 STEM are growing job fields</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.2 Gives the child the knowledge to choose a career</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.3 STEM is a huge part of life</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.4 STEM provides more career opportunities</td>
<td>5</td>
</tr>
</tbody>
</table>

**Theme 1: Factors influencing interest in a STEM Career.** Using magnitude coding, the factors students listed under the question, “*Name in order the three biggest influences on your choice of career in the future,*” is shown in Table 27. The first column
shows the frequency at which a particular factor showed up in the pre survey and the second column shows the frequency in the post survey. The third column shows the total frequency in both surveys. The factors are arranged from highest to lowest frequency based on the total frequency in both surveys. Additionally, the only factors shown here are those that had 4 or more combined occurrences between the two surveys.

Table 27

The frequencies of the factors influencing student interest in STEM

<table>
<thead>
<tr>
<th>Factor</th>
<th>Frequency in the Pre Survey</th>
<th>Frequency in the Post Survey</th>
<th>Total Frequency in both Surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM</td>
<td>11</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>Parents</td>
<td>8</td>
<td>10</td>
<td>18</td>
</tr>
<tr>
<td>Family</td>
<td>7</td>
<td>9</td>
<td>16</td>
</tr>
<tr>
<td>Friends</td>
<td>5</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Hobbies and Interests</td>
<td>7</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Teachers</td>
<td>5</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Money</td>
<td>4</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Role Models/ Influential People</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>School</td>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>STEM Camps</td>
<td>1</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Grandparents</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Siblings</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Grades</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Self</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Nature/ The Outdoors</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

The themes emerged from everything the participants talked about in the surveys, as well as their daily journals. There were dozens of factors that were mentioned, but as was shown in Table 27 above, the strongest influence on students' interest in STEM are the subjects incorporated under the STEM umbrella. This was mentioned 20 times between the two surveys. Other strong influences include parents, family, friends and
teachers. Those factors appeared 18, 16, 13 and 11 times respectively. Additionally, hobbies/interests appeared 13 times, which is tied with friends. Additional strong factors included money, role models/influential people, school and STEM camps. Those factors appeared 10, 8, 7 and 6 times respectively.

There were also a lot of factors that appeared less than 4 times including, but not limited to, personality, abilities/skills, movies/television, grades and helping people.

After coding the data and analyzing the results, it seems that there were numerous factors that affected students’ interest in a career involving STEM. Looking at the two open ended questions in both the pre and post surveys, “Are you interested in a STEM (Science, Technology, Engineering and Mathematics) career? Why or why not?” and “I would like you to write about your experience with STEM (Science, Technology, Engineering and Mathematics) field”, students had very insightful replies. Their interest, or lack of interest, seemed to stem from various reasons including, being interested in working with their hands, to being good at those subjects, to having good teachers. Those various reasons were grouped into the subthemes shown in the coding table.

A lot of different reasons and factors fall under the subtheme, “Hobbies, personal interests, having fun, grades and abilities”. All of which are related to the students themselves, their personality, and their interests. Out of all the factors, this subtheme appeared the most with 107 occurrences. The graduate student who conducted the coding wrote a memo in the coding software saying, “Up to this point, I feel like internal motivation is a strong influencer.” This is mirrored in the number of times this subtheme emerged, which is much higher than any of the other subthemes.
In the area of working with their hands, and wanting to know how things work, one of the students said, “YES I AM, A HUNDRED TIMES YES. I love how I can make things to feel accomplished and hands on activities which get me to think through things and work with others.” Similarly, other students said, “Yes, because I like to know how things work and make and test things,” and “I love everything with hands on crafting, experiments, creations, and everything to do with stem.”

Regarding, being good at those topics, and enjoying them being the reason for the interest, a student replied, “I am. STEM fields have always been my strong suit. They come natural to me and make lots of sense unlike other fields.” Another student said, “Science is one of my favorite subjects. We always learn more every minute.”

Other students mentioned fun as a strong factor affecting their interest in STEM with one student saying, “Yes, because science has always been very fun and fascinating.” Another student said, “I am interested in STEM because of the fun things that we do.”

Combining, fun and hands on learning as important factors, one student said “I typically do very good in classes related to these topics, even though I’m not very fond of the classes that are only numbers on paper (as in math). I really enjoy the classes where I can work hands on. I like to be able to work with my hands rather than a pencil, I like fixing machinery and figuring out solutions to their problems.”

One student cited the lack of ability to be a factor influencing the lack of interest in STEM saying, “Nah because I’m a slow learner.” While another student said that right now school work is their main concern, not their future career saying, “At this point in life I don't think much of my career because of the school work.”
Finally, one student put down a detailed and well thought out reason for their interest in STEM, which included a comparison with some non-STEM fields saying, “I enjoy work in the STEM areas and activities using these different subjects. I feel that when they are put together or paired up they are a lot more fun, and each of them are challenging in their own way. I especially love these areas because they are hands on, fun ways to learn. While in language/arts you read and write about what you learned. This is fun because you can use your imagination, but STEM takes it to the next step. You can build and create things using set strategies and equations, but there is also a side where you can use your imagination.”

The subtheme, “Family and Extended, Friends, Teachers, influential people” is regarding role models or people that have influence on students. This includes; immediate family members such as parents and siblings to extended family, to their teachers at school, to their friends and peers, and influential people, usually from TV. This was the third most common subtheme, with 45 occurrences. One student said, “Both of my parents have a STEM career. So, I have a constant influence throughout my life. Every person in my family was in the military instead of going to college. I want to be the one that changes that.” Another student said, “Seeing the things that engineers in my family have done.”

Another student discussed the reason for their interest in STEM being, “My math teacher last year (Mr. Smith the best teacher ever) got me interested in math which I usually hate.”

The subtheme, “Money, Future Career, and Applicability” encompasses future choices for the students regarding which career they want to be in, how applicable that
career is in life, and how much money they would like to make. This was the second most common subtheme with 71 occurrences.

A reason for interest in STEM under this subtheme is, “wanting to make the world a better place”. One student said, “Yes, because I want to make a world for others to live in.” Similarly, another student said, “Yes, because it interests me, and I want to make a difference in the world.”

Conversely, other students cited money as the reason for interest in STEM, with one student stating it outright saying, “Yes I am. I think that most careers in STEM are big money earners.”

Other students cited more general reasons for their interest, including a student saying, “Yes, I think these specific careers are the best. There are so many to choose from, so many things to do, and you can even come up with something and adjust what it is to fit your interest.”

Some students already have a plan in mind as to what career they would like to go into, whether it is a STEM, or non-STEM career. Examples of students talking about their future career included, “Yes I want to be a genetic engineer because I think it would be very cool.” Similarly, another student said, “Extremely, I would want to become an Astrophysicist.” Another student said, “Yes. I really want to build cars for either Tesla or GM.” Moreover, another student said, “Yes, I want to be a computer programmer, so I guess that falls under the tech.”

One student had a particularly interesting reason for being interested in STEM saying, “I want a job as a programmer so that falls under tech, so I do want a stem job. I am interested because I love mine-craft.” Minecraft is a famous and widely successful
video game that was programmed by one person, and have since sold more than a 140 million copies worldwide. The game has a simple premise of freeform building using blocks you can gather around the game world. For this student, it appears that their interest is generated through the game, combining programming skills and engineering/building skills, as well as imagination, since the game is completely freeform and does not restrict the player’s ability to build whatever they can imagine.

However, other students explicitly stated being interested in other careers as the reason for not being interested in STEM. One student said, “No, I want to be an artist.” And yet others stated that they have no future plans in terms of career as of yet with one student saying, “At this point in life I don't think much of my career because of the school work.”

One other student talked both about being interested in a specific career, but also helping others through that career and said, “I am interested in the engineering part of the stem career because I want to learn how to create things that will help others”.

The fourth subtheme is “School, STEM camps and activities”. This includes anything related to school, and STEM-related camps and activities the students participate in through their schools. This theme is tied for third most common with 45 occurrences.

Students mentioned some of the STEM-related camps and activities they have done in school. One student said, “when I was in elementary I was in stem, in junior high I was in mesa,” while a female student said, “I did SheTech we learned about different subjects in the field of science tech and engineering.” She moved on to say, “I am wanting to become an astrophysicist. It is my love to look and study space and everything
in it. I'm hoping to become the first woman on Mars.” Those comments show that camps specifically targeted at female students could be very effective in increasing their interest into those fields.

One student had an interesting perspective that maybe schools are pushing STEM too much to the point that some students are turned off saying, “My school is really big with STEM. I think that it can help many kids find great careers when they grow up. Sometimes I feel that they push STEM too much to where some kids dislike stem (not including me).”

The final subtheme is “Nature, animals”, with a couple of students citing this as a strong influence on their choice of career. One student said, “I wanna be a vet because I love animals. I want to help animals.” Only two students mentioned animals or nature, and was not considered as a very strong factor. However, both students were female, and that aligns with females’ interest in wanting to be in more caring or nurturing roles. This is discussed further in chapter 5.

**Theme 2: Changes in perception about STEM.** This theme emerged from everything the participants talked about in the surveys, as well as their daily journals. A major question, in providing the data for this theme, was the question “Which of today’s activities affected your thinking about STEM (Science, Technology, Engineering and Mathematics) fields? How did it change?” This question was part of the daily journals students completed during the camp.

While there were some positive changes, there was also a lot of students that reported no change in perception, and some that said they did not know their perception
changed. Starting with the two subthemes “I do not know” and “No change”, those two subthemes had the frequencies of 6 and 26 respectively.

The subtheme, “Learning activities changed perception/interest.” tells the story of students who, as a result of attending the camp, had a change in perception regarding STEM. This subtheme in perception change showed up more than all the other subthemes combined, with 59 occurrences.

Many of the data coded under this subthemes centered on students mentioning or discussing certain activities that changed how they perceived STEM. One of the students said, “The water activities we did today was really cool and it changed my thought about water.” Another student expressed a similar sentiment saying, “Making the water filters changed my thinking of technology because it showed how we need it to make healthy water.” A third student shared a similar perspective, “Testing the water affected my thinking about STEM the most. By teaching me all about it and how to do it. It also makes my liking about STEM go up too.” A student seemed particularly happy and excited with what they learned saying, “All of the testing and taking notes made science so much more fun for me. It is exciting to study creatures and water.”

Some students expressed that they did not expect STEM to be fun, but some of the activities changed their perception about how participating in STEM activities can indeed be enjoyable. One student said, “Tagging a fish. It made me think it is fun.” Another student said, “It made science fun.” A third student mirrored those thoughts saying, “Yes today’s activities affected my thinking about STEM because I learned so much new things that were really interesting.” While yet another student stipulated that
STEM can be fun when you’re knowledgeable about it saying, “STEM is a blast when you know the right stuff.”

Two students said that they thought STEM was boring, and not fun, but the activities changed their minds. This was expressed in their answers to the prompts in the daily journal “Before today I thought,” “but now I think.” The first student responded to those questions as follows; “All science was boring” followed by “Not all science is boring”. The other student said, “It was gonna be boring” followed by “Its interesting to learn about those things.”

Some students expressed that they did not know the extent, or the complexity of STEM subjects, and they expressed that in a positive way. One of the students said, “It is very interesting and more complicated than I thought.” A second student echoed that thought saying, “I think today’s activities made me think STEM matters more. I used to think all STEM stuff was simple, but it is really not.” A third student made a similar comment, although more specific to water than STEM in general saying, “There is a lot more to water than the average person perceives.”

For some students, the camp activities changed their perceptions about STEM, and got them interested in asking questions they were genuinely curious to learn the answers to. Some of those comments related to an experiment regarding iron in water, with two students asking a similar question, one of them said, “Bacteria is interesting and I want to find out why iron in the dirty lake water was floating rather than sinking.” The other student shared a similar curious question saying, “When our iron floated to the top instead of bottom it brought so many exciting questions.”
Other students started thinking creatively about possible applications from what they learned, with one student saying, “Engineers have so much room to grow in water filtering” with another student putting a goal for themselves saying, “That we use engineered water. I want to make a cheap thing that makes water the purest to drink.” It was interesting that this student wanted to make something cheap that filters water, not just something that filters water which means they were thinking about the economical side, not just the technical side. Another student wanted to apply the bead activity in some way saying, “The water cycle bead activity, it has me thinking of ways to get water where we truly need it.” Similarly, this student seemed to be thinking of, not just the technical side, but also the needs of society, in terms of water. Another student made the comparison between beavers and engineers following a visit to a beaver dam saying, “I never thought about beavers and how they are engineers.”

Interestingly, some students seemed to have a negative experience, mostly related to the visits to the waste water treatment plants. One student said “Kind lowered my interest.” While another student said, “The waste place tour. It made me realize STEM could be nasty.” Those two responses were outliers as most of the responses were positive. However, it was worth mentioning them, as they mirrors the rating students gave to the activities, with the visits to the waste water treatment plants scoring very low.

Conversely, some students actually commented positively on the waste water treatment plant visit, with one student saying, “Going to the lagoon. It shows me that there is much more to the world than we thought.” This student seems to have looked beyond the superficial and unlikable characteristics about treatment plants, and realized their importance and place in the world.
The subtheme “Learning what STEM professionals can do” showed up when students reported learning more about what STEM professionals do on the job, and how this changed their perceptions about STEM. This subtheme had 17 occurrences.

Data coded under this subtheme centered on students discussing what they learned about STEM professions during the camp. One student commented on what they learned about Engineers without Borders saying, “It made me think about the fact they do the engineering without borders to help the world in their need for safe drinking water.” Another student commented on how much thought and effort they thought engineers have to put into their work saying, “The engineers don’t get enough credit, they have to map it and use lot’s of calculations.” A third student commented about scientists testing water saying, “Testing the water, I now know how scientists test water.”

Another student talked about how the camp activity made them understand how STEM fields work together saying, “Stream flow and chemistry shows me how science technology, engineering and math fit together, work together.”

Once again, students commented about the water treatment facilities. It is interesting that while many students had a negative impression of the visits themselves, some of them also expressed positive thoughts towards the science involved, and the people doing that work, with one student saying, “Cleaning water is really hard, and I am super grateful towards the people who work every day to clean water, because I would never do the job myself.” Another student said, “The treatment plants affected my science view about water treatment, I am now more informed.”

The final subtheme, “Learning a lot in the camp reinforced/changed the choice to go” was uncommon, and only showed up 6 times. Under this theme, students expressed
their interest to go into STEM, mainly as a result of the camp activities. Two students explicitly state their interest to go into a STEM, career with one student saying, “I want to do engineering more.” Another student said, “It kinda makes me think I want to become a scientist.”

Others were not as explicit, but had a lot to say about the camp activities, and how it affected them, with one student saying, “During this week my experiences changed a lot with stem. Before this week I never thought that there was so many ways to do things and I didn't really like STEM that much But as I went through the process of everything and really got to enjoy it then yes my experiences changes.” This student went on to answer the question about interest in a career in STEM with, “Yes, I am interested in STEM I like the fun activities that they provide and the really fun camps we get to go to.”

**Theme 3: Learning new STEM content at the camp.** Theme 3 emerged from everything the participants talked about in their daily journals. A major question in providing the data for this theme were the questions, “What have you learned today?” This question was part of the daily journals students completed during the camp. However, as this theme does not help answer any of the research questions, the results were coded and analyzed, but will not be reported, aside from the frequencies of each sub-theme.

*Fish Tagging, 29 occurrences*

*Water Cycle and Watersheds, 76 occurrences*

*Building a water filter and water Treatment, 136 occurrences*

*Incidental Learning, 30 occurrences*
Theme 4: Parent Perceptions about STEM. Theme 4 emerged from everything the parents talked about in the pre and post surveys. The major question in providing the data for this theme was the question, “What are your thoughts on the importance of STEM (Science, Technology, Engineering and Mathematics) for the future of your son/daughter?”

Parents’ perceptions about STEM were almost exclusively very positive. One comment that stood out as more neutral, or leaning towards non-STEM was, “I believe Science, Technology, Engineering and Mathematics are important but I also believe that the arts need to be in their education also to help balance out everything.”

The subtheme, “STEM are growing job fields” relates to parents discussing how STEM is growing, and an important part of the job market. This subtheme had 2 occurrences, with two parents expressing their thoughts on how STEM jobs are growing, with one parent saying, “Future successful careers are STEM based so it is vital to have as much exploration and learning as possible in that area.” Similarly, another parent stressed the importance of STEM in the job market saying, “I believe that the demand for workers in STEM careers will continue to increase as we continue to advance as a society. My daughter has a talent for science and math, and if she decides to pursue a STEM career, I foresee her having many opportunities in her future. I am glad that the STEM industry today (as a whole) really seems to encourage females in these fields.” It is especially important to note that this parent is happy that the STEM industry today seems to encourage females in those fields.

The second subtheme is, “Gives the child the knowledge to choose a career”. This subtheme showed up 10 times, and was related to parents discussing how this kind of
camp gives their children the knowledge to make an informed choice with regards to their career.

One of the parents said, “I hope that this will open his eyes to a new world and maybe pursue a great career.” A second parent said, “We are excited for our son to learn and discover the different areas STEM has to offer so he can choose his career wisely.”

A third parent echoed the same thoughts saying, “I believe that it is special opportunities like these that will help my son to determine the direction he should be focusing his studies.” Another parent was more specific regarding STEM, and specifically math saying, “Math has always been my weak spot but hey I think my daughter should get all the learning she can until she finds something she likes and can make money at it.” From these quotes, it appears that parents agree that opportunities like the engineering camp are important for middle and high school students, to help them with their career choices.

One parent already knows what specific field of STEM their son is interested in, and thinks this kind of program is helpful, “I believe that STEM is a very important program that will begin to set the wheels in motion for my son to pursue his dreams of becoming a genetic physicist. I am thrilled and excited to hear about all the wonderful things he learns while attending this program.”

One parent was very detailed about how they think STEM camps helped their son, saying, “He came home with a much more clear understanding of the world around him and a strong desire to do more to improve our world for future generations. My son always loved science. In fact he excels in it. Since he was in 2nd or 3rd grade he told me he wanted to be either a genetic scientist/physicist or an architectural engineer. I feel it is
important for my son to pursue his dreams-whatever they may be- in his case it is science and engineering, so in my opinion STEM is a high priority for his future.”

The third subtheme is “STEM is a huge part of life”. This subtheme appeared 10 times, and focused on parents talking about their perspectives about the importance of STEM, and how it represents a large part of our lives.

One of the parents expressed this point really well saying, “STEM subjects are a huge part of our lives. I want my child to be successful in a career and I see that happening if he pursues a STEM career.” Other parents echoed those thoughts, with one parent saying, “The importance of STEM gets bigger every year. I think it will be very important to have knowledge in these areas as the world keeps advancing.” Similarly, a third parent said, “STEM affects our daily lives now, I don't see that changing in the future.” Another parent shared similar thoughts and said, “I think STEM is very important for the future of my son because of the constantly changing world we live in.”

Regarding learning about STEM, since it is very important, some parents made the following comments, “Almost any career held by my child will be enhanced by learning to think through things from a STEM perspective even if they do not pursue a specifically STEM oriented profession. Even if their main career is as a mother and homemaker.” And another parent said, “It is very important...it should be taught throughout all of their schooling. It is where our future lies.”

However, another parent put it differently, not putting additional emphasis on STEM, but rather on their child being knowledgeable in a lot of things, and said, “It's important for our children to be well rounded.” While I agree with the importance of STEM, I do also believe that children should be well rounded, and be taught both STEM
and non-STEM fields to ensure their competitiveness and them having a broad range of knowledge.

The final subtheme was, “STEM provides more career opportunities”. This subtheme showed up 5 times. Parents discussed how they think STEM is related to careers, and having opportunities in the workforce.

One parent said that STEM is in everything, so naturally it would pave the way for a lot of career possibilities saying, “Everything involves science, technology and engineering. It opens up a lot of career opportunities for the future.” Other parents seemed to be well informed about the job market, with one parent saying, “I believe those fields are very important. Most jobs today are focused in those areas.” While another parent put that in detail, “I believe that the demand for workers in STEM careers will continue to increase as we continue to advance as a society. My daughter has a talent for science and math, and if she decides to pursue a STEM career, I foresee her having many opportunities in her future. I am glad that the STEM industry today (as a whole) really seems to encourage females in these fields.” A third parent put it in a short and simple, but straight to the point way saying, “It opens doors that he is interested in pursuing.”

Overall, it appears that parents have a generally very positive perception about STEM, and believe that attending a STEM camp is worthwhile, and that going into a STEM career would be a good and rewarding choice.

Summary

This research aimed at finding whether attending a summer camp would increase students’ interest in STEM, improve parents’ perception of STEM and find which factors affect the students’ interest.
Results showed that the students experienced an increase in perceived interest in STEM as a result of the camp. Students who started with low interest, and females experienced larger increases than the full sample.

Parents’ perceptions of STEM were high before the camp started, and that perception improved slightly as a result of their child participating in the camp.

Factors influencing students’ interest vary, and include internal influence such as ability and interests, to external factors such as family and friends. However, based on the data and the findings, internal influences seemed to be stronger than the external influences.
Chapter V

Discussions, Implications and Recommendations

Effectively recruiting students into STEM fields is a national concern in the United States. Today, many students are not interested in STEM fields, and thus there are not enough STEM graduates to satisfy the needs of the job market. This study investigated students’ interest in STEM, the factors influencing this interest, or lack of interest, as well as students’ parents’ perception about STEM.

Students attended a week-long engineering camp at Utah State University, with the aim to increase their interest in STEM, and investigate what factors influence this interest. Their parents were also involved through a daily blog that included a summary of the camp activities, as well as pictures and quotes from the students.

The researcher compared the results of the pre and post surveys completed by students to determine if there was a significant gain in their interest in STEM, as well as what factors influenced this interest. The researcher also compared the results of the pre and post surveys completed by parents to determine if there was a significant gain in their perceptions towards STEM fields. The results of this study could aid future researchers in designing future camps. The results of this study point to some demographic groups that could benefit from STEM camps. The results also point to which factors seem to be most influential in students’ choice of career. Designing future camps keeping the results of this study in mind could potentially help students to consider STEM careers as good options as they move into their adult life, and/or begin their college career.
Discussions

Research Question 1. The first research question was, “Does a summer engineering camp experience affect the perceived level of interest of secondary school students in STEM fields, especially those who enter the camp with a low perceived interest level? And how does it affect their interest?”

To answer this question, both quantitative and qualitative data were used. Looking at the quantitative data first, it was clear that students experienced an increase in perceived interest in STEM, there was an upward and often significant change in interest among all participants. However, it appears that students who came to the camp with low interest in STEM careers made much larger gains than the students who started the camp with high interest in STEM. The ceiling effect may be a factor, as the survey questions were on a 5 point Likert scale, and those students who started with high interest in STEM were already near the top of the scale in terms of their interest, leaving not much room for improvement.

For the subgroup that started with low interest, their interest gain was significant on all but one question. The only question that was not significant was, “I plan to use technology in my future career”, which had a p-value of 0.057. The same question had a p-value of 0.4470 when looking at the full sample of students. This may be due to the way the camp activities were designed to focus on science and engineering as well as doing mathematical calculations. Additionally, as shown in Table 7 in Chapter 3, the mentors designing and delivering the camp activities were mostly from science and engineering backgrounds, with no mentors coming from a technological background.
Comparatively, students who started with higher interest, had multiple questions with significant gains in interest, and multiple questions that were not significant. The gains in a few questions were not significant, when looking at the full sample of students, but those same questions became significant, when looking at only the subgroup that started with low interest.

The results indicate that a good way to conduct future STEM camps is to attempt and target the students who have average or low interest in STEM, not students who have already made up their minds on a career in STEM. This may be challenging, as participation in STEM camps is typically voluntary, and students who participate generally do so because of their interest in STEM. However, working closely with parents, teachers and students can aid in determining which students are not currently interested in STEM, and target recruitment to those students to attend STEM camps.

Students entering the camp with high initial perceived interest is similar to the observations by Hernandez et al. (2014), and Stake and Mares (2001). Students starting with low interest, and having significant gains, compared to their peers with high interest, is similar to the findings by Hernandez et al. (2014).

When comparing males and females, it was clear that females gained more from the camp than males. This is similar to the findings by Stake and Mares (2001). While there was an upward trend in interest for both males and females, generally females experienced more significant changes. At the start of the camp, males had higher interest in STEM, but at the end of the camp, females had higher, or at least equal interest in STEM. This trend indicates that females may have more to gain from STEM camps, and as such, future camps should be designed to be more attractive for female students, and
planning activities geared more towards females. As noted by Archer et al., (2013),
females tend to gravitate towards careers that have caring/nurturing roles, and where they
help to make the world a better place. Similarly, Carlone and Johnson (2007) found that
females tend to be more interested in careers where science and altruism overlap.
Designing camp activities that show female students that STEM careers can offer that
role may be helpful. A faculty member attending a research seminar at Utah State
University, where the preliminary results of this research were presented, commented that
camps with a biological and environmental nature tend to attract female students into the
biological side of the sciences and engineering, and so camps designed with that in mind
tend to be effective.

From the students’ answer to the question regarding how the camp influenced
their choice of career, only 2 students indicated that the camp made them change their
career choice to a STEM field, and no students changed their mind to go into a non-
STEM field as a result of the camp. The majority said that the camp reinforced their
choice of career with 21 students picking that option. Out of those 21 students, 19 said
they are interested in STEM careers, and that the camp only reinforced their decision.
The other two students were interested in other fields, and the camp did not change their
decision. Out of the 8 students that said the camp had no influence on their decision, four
had decided on a STEM career, and the camp had no influence on that decision, while the
other four had chosen non-STEM fields, and the camp had no influence on their decision.

Students’ ratings of the camp activities also gave important information that
echoes general consensus, that students are more inclined towards active learning rather
than passive learning. This was reflected in their ratings of the activities where the
activities where they were most actively participating were rated highest such as “Building a water filter” and “River/watershed experiences”, while activities where they were more passive listeners, such as the two visits to the treatment plants, were rated quite low. The conclusion from this finding is that future camps should be designed with as little passive learning as possible.

Looking at the qualitative data, the trend was similar to the quantitative data, and most of the students expressed their interest in STEM both before and after the camp. However, the post camp replies were more specific, and showed some of the potential effects of the camp. In the pre camp survey, some sample replies to the question “Are you interested in a STEM (Science, Technology, Engineering and Mathematics) career? Why or why not?” included, “yes because it is fun”, another student said, “Maybe if I can’t be a firefighter. I be willing to do it.” A third student said, “Maybe, I don’t know what careers involve STEM.” There were also some very specific answers in the pre survey, such as a student saying, “Yes, I am. I want to be an engineer because I enjoy finding out how things work and, I also like math. I sometimes find math class boring, but I find math itself enjoyable.”

At the time of the post survey, students seemed to have more of a grasp on their interest in STEM, and provided more detailed answers. There were still some general replies such as, “Ya, I enjoy STEM and I have a lot of fun with these types of things.” And, “Yes because I enjoy doing activities in the areas.”

However, there were also a lot of very specific and well-thought out replies to the question, including one student saying, “Yes, I think these specific careers are the best. There are so many to choose from, so many things to do, and you can even come up with
something and adjust what it is to fit your interest.” Another student commented on the camp itself as a reason for their interest saying, “Yes, I am interested in STEM, I like the fun activities that they provide and the really fun camps we get to go to.”

Other students were very specific, and talked about a certain career they are interested in, with one student saying, “I am interested in a STEM career because I think it is challenging and it helps me and encourages me to try harder in school. I am interested in Biomedical Engineering, so I will have to try hard in STEM fields at school.” Another student said, “Yes I am interested in a STEM career. The reason why I am interested in a STEM career is because I like engineering and I know it is a great pathway for careers.”

The qualitative data provided strong evidence that the camp influenced students’ interest in STEM, and is shown in student responses to the question, “Which of today’s activities affected your thinking about STEM (Science, Technology, Engineering and Mathematics) fields? How did it change?” In the daily journals, some students said that through the camp activities, they are more interested in STEM for a career. Sample quotes about this include one student saying, “I want to do engineering more.” Another student said, “It kinda makes me think I want to become a scientist.”

Another student was not as specific, but had a lot to say about the camp activities and how it influenced their view of STEM, with one student saying, “During this week my experiences changed a lot with stem. Before this week I never thought that there was so many ways to do things and I didn't really like STEM that much, But as I went through the process of everything and really got to enjoy it then yes my experiences changes.”

This same student provided an answer to the question about interest in a career in STEM
saying “Yes, I am interested in STEM. I like the fun activities that they provide and the really fun camps we get to go to.”

Both the quantitative and qualitative data show consistency in students showing high interest in STEM, both before and after the camp, with slightly more interest gained through the camp. The results show that a summer engineering camp can increase student interest in STEM, and the result of the research is similar to other STEM research. In a study by Laut et al. (2015), the results of their surveys show that students who participated in outreach program have more interest in going into STEM fields. Abaid et al. (2013) observed similar results, and they concluded that summer workshops, where students learn about engineering outside the school environment, have been largely successful in increasing interest in STEM fields. The importance of STEM recruitment was stressed by Yates (2013), and Babb et al. (2014), and their findings were similar to other studies. They concluded that outreach programs targeted at the high school level generally raises awareness and yields more interest in engineering. Similar results were found by Yilmaz et al. (2010).

**Research Question 2.** The second research question was, “*What factors influence students’ interest, or lack of interest, to pursue a career in STEM fields?*”

To answer this question, both quantitative and qualitative data were used. Looking at the correlation coefficients, it is clear that students’ overall interest in STEM, as well as their perceived ability to do well in it, their ability to get good grades in STEM subjects, and complete STEM-related activities, showed the strongest correlations. Additionally, how much they liked participating in STEM activities played a strong role in their perceptions and interest. Another strong factor was the perception of their friends.
A powerful STEM recruiting tool may be to work with students who are interested in STEM, to convince their friends, who may not be interested.

Interestingly, factors that are often touted as strong influences on a students’ choice of careers were not very strong in this study. Those included; parents’ perception, income and education, level of STEM engagement, the first time the students had engaged in STEM, and role models. This is similar to results found by a college-level study sponsored by Microsoft Corporation (2011). They found that students having a passion for STEM, and studying hard, were the most important factors affecting their interest in STEM. The authors also found that external factors, including mentors and role models, were actually less important. This could be due to the idea that mentors and role models have a large role to play in children’s development and life, which may be hard to quantify. This could explain why those factors scored low in the quantitative data, but scored high in the qualitative data.

The qualitative data paints a similar picture with the various STEM fields being the strongest and most mentioned factors for students’ choice of career. Many students simply said that the subjects and fields of science or engineering were the strongest factors influencing their interest. However, the qualitative data differs from the quantitative data when it comes to parents and family being strong influencers. The quantitative data showed that parents were not a very strong influence on interest, however in the open-ended questions, students said that parents, siblings and family members in general were strong influencers. While other researchers; Miller and Pearson Jr (2012), found that the parents’ educational level was a strong influence on their children taking advanced math/calculus in high school and proceed on a pathway into
STEM fields, this research showed a weak correlation between the parents’ education and income levels and students’ interest.

This may be due to the fact that the numbers of parents who completed the pre and post-survey was not sufficient data to show the correlation properly. Additionally, the influence of parents is likely too complex to be measured in quantitative form as the questions about parents’ perception of STEM, their income, and their education, aren’t the only factors that influence the complex relationship between parents and their children, and thus the quantitative data may not have been able to identify parents as a strong influencer. The qualitative data explicitly asked about which factors strongly influence their career choice. Parents, family members and role models all came in the top 10 strongest factors, with parents coming in at number 2.

This aligns with the findings of Yun et al. (2010) who concluded that parents are the front line with regards to the education of their children, and are important agents in the development and educational achievement of their child in a formal setting.

Parents read books to their children, take their children to zoos, aquariums and museums, and interact with their child on a daily basis. A familiarity with STEM fields can influence the parents’ ability and strategies when teaching their children (Yun et al., 2010).

Similarly, Goodman and Cunningham (2002) found that mothers and fathers were a strong influence in their children’s decision of major, with over 70% of study participants citing a parent as the most or second-most influential factor in their decision.

The results, comparing the top ten influencers on interest in the qualitative vs quantitative data, yields the results shown in Table 28 below.
Table 28

*The top 10 factors influencing interest in STEM from both the quantitative and qualitative data*

<table>
<thead>
<tr>
<th>Top 10 factors as shown by the quantitative data</th>
<th>Top 10 factors as shown by the qualitative data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ability in STEM related activities</td>
<td>1. STEM</td>
</tr>
<tr>
<td>2. Ability in Engineering activities</td>
<td>2. Parents</td>
</tr>
<tr>
<td>3. Enjoying activities involving STEM</td>
<td>3. Family</td>
</tr>
<tr>
<td>4. Willingness to working hard in STEM classes/activities</td>
<td>4. Friends</td>
</tr>
<tr>
<td>5. Getting good grades in STEM classes</td>
<td>5. Hobbies and Interests</td>
</tr>
<tr>
<td>6. Friends perception of Science</td>
<td>6. Teachers</td>
</tr>
<tr>
<td>7. What their parents would think of them having a STEM career</td>
<td>7. Money</td>
</tr>
<tr>
<td>8. Ability to get good grades in Math</td>
<td>8. Role Models/Influential People</td>
</tr>
<tr>
<td>10. Attending STEM camps</td>
<td>10. STEM Camps</td>
</tr>
</tbody>
</table>

Looking at Table 28 above, it is clear that internal factors such as ability, interests and hobbies are very strong influencers, and occupied seven out of the top 10 factors obtained through the analysis of the quantitative data. They also occupied three out of the top 10 factors as obtained through the analysis of the qualitative data. Interestingly, attending STEM camps came in at number 10 in both the quantitative and qualitative results. This shows that STEM camps are well worth the effort, and do improve students’ interest in STEM.

Friends scored highly in both quantitative and qualitative results coming in at 6 and 4 respectively. This shows that friends consistently have a strong influence on each other, and this knowledge can be used in recruitment as discussed below.
The results are similar to findings by Sahin et al. (2015), who found that the strongest influences on students were teachers, personal interests, and parents, respectively. They discussed other factors based on the literature. Those factors included; job security, personal interest, job satisfaction, difficulty levels of preparation courses, and relationships-based influences from friends, parents and role models.

Similarly, Moore (2006), found that students’ interest in mathematics, science, technology, and engineering correlate strongly with them going into engineering majors.

Similarly, Franz-Odendaal et al. (2016) stated that the influences on children’s career choices include, dryness of the subject matter, parental influence, teacher influence, peer pressure, adolescence, lack of career awareness, and lack of the realization of the relevance of science education to their lives.

Some of the student quotes indicate that STEM subjects are a key factor on their interest include: “STEM fields have always been my strong suit. They come natural to me and make lots of sense unlike other fields.” Another student said, “Science is one of my favorite subjects. We always learn more every minute.”

**Research Question 3.** The third research question was, “How does a summer engineering camp experience attended by their child affect parents’ perception of STEM fields?”

To answer this question, both quantitative and qualitative data were used. Looking at the quantitative data first, parents had a positive perception of STEM before the camp, and that positive perception continued after the camp. This is due to the fact that most parents had a very high perception of STEM at the outset of the camp, as most of their responses on a 5-point Likert scale were 4 or 5. Because of this, no significant
difference was found between the pre and post survey. Another factor was the small sample size, as most of the parents did not complete the post survey. There were only 24 parent post survey’s completed, however, it was clear that the trends were positive.

This is especially true for the question, “I want my child(ren) to pursue a career in engineering”. This question is of particular importance, as a major point of the camp was to increase student interest in STEM, particularly engineering. The results of this question changed from an average of 4.15 on the pre survey, to 4.42 on the post survey. The results were not significant due to the small sample size, but it was still the largest change in the parents’ surveys between pre and post surveys. This kind of camp, with limited parental involvement through the parents accessing the daily blog posts, did increase parents’ likelihood to want their children to pursue a career in engineering. Whether this leads to parents being more actively involved in guiding their children towards a STEM or engineering career, cannot be measured by this study. This would be valuable information to improve the STEM pipeline, but would require additional research involving more participation with parents. This is similar to findings by Klein-Gardner (2014).

The qualitative data provided by the open-ended question in the parents’ survey, mirrored the results from the quantitative data. Most of the parents had very positive thoughts and perceptions about STEM, both in the pre and post survey, leading to the belief that parents had a strong positive opinion of STEM before the camp even started. Sample quotes from parents, that show their high perceptions of STEM, include one parent saying, “Future successful careers are STEM based so it is vital to have as much exploration and learning as possible in that area.” Another parent echoed those
sentiments saying, “Everything involves science, technology and engineering. It opens up a lot of career opportunities for the future.”

While some parents commented on how they were following the camp, and discussed it with their children after they returned home, one parent said, “I believe that STEM is a very important program that will begin to set the wheels in motion for my son to pursue his dreams of becoming a genetic physicist. I am thrilled and excited to hear about all the wonderful things he learns while attending this program.” Another parent said, “He came home with a much more clear understanding of the world around him and a strong desire to do more to improve our world for future generations.”

One of the parents commented about the effect the camp had on their child, saying, “I've been very impressed with this entire program. The dedication and the skills that have been taught to my son are invaluable and so much more than expected. My son commented that it was so nice to be able to learn in smaller groups. He said he was able to ask more questions and get a much more one on one experience with the instructors. He also got a taste of what college life is like, which was an eye opener... not having mom there to wake him up each morning. Overall, I believe this program was a great success and we are grateful for the opportunity to be a part of it. He absolutely loved it and couldn't stop talking about it. He would tell complete strangers at the store etc. about all the wonderful things he learned and what a great opportunity it was for him. Fabulous Program!”

Overall, it was clear that parents had a high perception of STEM before the camp and that perception only improved as a result of the camp, despite the limited involvement by parents.
Implications

It is clear that the summer engineering STEM camp had a dramatic effect on students’ perceptions of STEM, and that there are factors that influence student interest. The effect was even greater for students who started the camp with low interest in STEM, as well as female students. Future camps should be designed to cater to female students, and should aim at recruiting more students who have low interest in STEM. This could be done using school-wide pre-surveys, to gauge students’ interest, before inviting them to attend a camp. Teachers could be used to help students who have low interest, or are on the fence regarding STEM to take notice of the available camps, and opportunities to learn more about those fields, and the potential for good careers. Teachers who attended those camps could share the experience, show the students pictures, videos and summaries of the activities, for example as shown on the blog. Teachers could also share what they learned in the professional development, and engage students in experiments that show what engineers and scientists do on the job.

Parents could be contacted to help recruit students that have low interest in STEM to attend those camps and see the opportunities when working in those fields. As an example of that, parents could be part of an intervention, similar to the work by Harackiewicz et al. (2012), where the researchers sent brochures and a link to a website to parents. All of this material was aimed at showing the parents the importance and usefulness of STEM courses. The authors found that students whose parents were part of the intervention group took, on average, one more semester of science or mathematics in high school than the control group (Harackiewicz et al., 2012). A simple intervention like
that, is very cost effective, and simple to do, and may have a large influence. Parents are an untapped source for increasing interest in STEM (Harackiewicz et al., 2012).

Using peer mentors, with an interest in STEM, could help in attracting those low interest students to STEM. The reason is that kids spend a lot of time with their friends, and are very likely to be influenced by those friends. This was shown in this research as friends’ perception of science scored highly as a factor influencing students’ interest. Similarly, friends were one of the strongest influences on the students’ interest in STEM, as shown by the qualitative data. Having friends who have attended those kinds of camps, or just have an interest in STEM, convey that to their friends may have a positive effect. Additionally, students planning to attend a STEM camp could convince their friends, who are not interested, to come with them, and through that intervention, their interest could increase.

This study, and previous studies, all point in the same direction, that outreach programs geared at giving students opportunities to participate in STEM activities, and giving them hand-on interactions with engineering and STEM professionals, can assist with STEM recruitment.

Parent involvement can help a great deal with STEM recruitment, as parents in this study, and in other studies, have a strong influence on their children’s decision-making. Parents should be more involved in the recruiting efforts, and be made aware of the need and benefits of STEM graduates. It may be possible to increase parental involvement through inviting parents to participate in STEM camps with their children. While this may be logistically difficult, with typical work schedules of parents, having parents participate in at least some activities, could be beneficial. An example might be,
at the end of the camp, when students present their work, parents in attendance would be able to see how much they learned, and how they are able to think and work as a team of scientists and engineers.

Peer adolescences have a strong influence on each other, as was shown in this study. Typically, kids have friends who are interested in STEM, and those who are not interested. Having those who are interested in STEM, attend a camp, and discuss the camp with their friends and peers, who they know are not interested, could change some minds and attitudes. This could include showing pictures of the STEM camp experience, letting peers see their notebook, posters, the blog, and so on. This, in turn, could help to attract those, with low interest, to attend future camps, and perhaps their curiosity would develop into interest. Additionally, with teenagers, these days, spending a lot of time on social media. Having students who attend a camp, post about their experience on social media, could potentially attract the attention of those who have little, or no interest in STEM, to attend future camps.

Summary of the Findings

The following bullet points summarize the findings of this research:

- Students experienced an increase in interest in STEM.
- Students starting with low interest in STEM, as well as female students, experienced much larger gains than the full sample.
- Many factors play a role in students’ interest in STEM. This includes internal factors such as enjoying STEM subjects, getting good grades in those subjects, and being interested in particular STEM subjects. Student interest in
STEM also includes external factors such as family and friends, and both of those factors have a strong role to play in students’ interest.

- Parents’ perceptions of STEM was high before the camp, and increases slightly as a result of the camp.

It is worth noting that most of the research results align with current literature. The most interesting finding, which is not prevalent in the literature, is students who started the camp with low interest. Only one of the studies focused on students who start a camp, or similar intervention, with low interest. This study, and the work of Hernandez et al. (2014), show similar results where students who start with low STEM interest have more to gain by attending camps geared towards increasing interest in STEM.

**Recommendations**

This study is part of a 7-year project with the intention of following students from middle school, all the way to college. While one of the objectives of the project is to find out whether attending a summer engineering camp increases interest in STEM, it also has the objective of finding out whether this interest is sustained, all the way to college, and whether or not it plays a role in the students’ choice of a college major. This was the second year of this project, and similar camps will take place every summer for the next 5 years. Collecting longitudinal data may assist in a more informed conclusion about the effectiveness of summer engineering camps in bolstering the STEM pipeline, and getting more students to choose STEM careers.

The findings of this research have led to several recommendations that can be made for future research. The first recommendation is to increase the student sample size, to get a more representative sample of Utah, or the United States in general. With a larger
sample size, power analysis can be conducted, and with a representative sample, the data can be generalized to other populations. In this study, the sample is not representative of the population, due mostly to the students volunteering to participate, which explains why most of the participants started with high initial interest in STEM. Another reason why the sample is not representative is that it was taken from students who are from low income families, which also does not represent the population of Utah, where there is low income, middle income families, and high income families. Additionally, the population of Utah, especially the sample participating in this camp, mostly consisted of White ethnicity, which made it impossible to explore ethnicity as a factor influencing interest. Having a larger sample, which is more ethnically diverse, would enable ethnicity to be a potential factor to be studied when it comes to interest.

A second recommendation is to target students who have low interest in STEM. While those students are not likely to participate in a STEM camp on their own, having friends who are interested in STEM, and planning to participate in a STEM camp, could convince there friend to join in the camp. This could assist in attracting more students not interested in STEM. Another method is to have students who participated in a previous camp tell their friends about their experience and encourage them to participate. Teachers could also play an important role in advocating STEM camps to students who show potential to succeed in STEM, but do not seem interested. An alternative recruitment method to use would be selective recruitment. This means recruiting some of the participating students with high interest in STEM, while other participants have low interest. Finding a “magic ratio” or “sweet spot” between the number of participating students who have low interest, and those who have high interest, may benefit STEM
recruitment. Having some students participate in STEM camps that are interested could potentially create an interesting dynamic, as students who have low interest benefit from the presence of students who have high interest.

A third recommendation would be to have more involvement that is parental. This was attempted in this research, but was shown to be difficult, as a large number of parents did not complete the pre or post survey. This is despite the number of reminders sent to them. Finding a way to get parents more involved could greatly help as the data showed that students see their parents and family as some of the strongest influences on them. Perhaps inviting parents to be involved in the camp, and not just students and teachers or having a more aggressive strategy. Creating a blog was successful as many of the parents did go and explore the blog, and looked at pictures. However, while that was good, it was a very passive method of involvement. A more active involvement from parents might prove very helpful. This could include simple interventions, such as sending parents material via brochures, or website links, or blog posts that show the importance of STEM. This potentially influences parents’ perception of STEM, and in turn, how they influence their children (Harackiewicz et al., 2012). Another way to achieve more active involvement would be to invite parents to attend, all, or parts of a STEM camp, such as if the camp was on a weekend, or invite parents for a short period of time to attend their children’s presentation and poster session. This would enable them to see what their child had learned through attending a camp.

To conduct additional research on student interest in STEM, there is a need to look at the student’s ability to conduct research. This includes the student preparing a hypothesis and designing a study around it, and presenting their findings. While in this
camp, students were taught to think and work like scientists and engineers, and they did come up with hypothesis, and then presented their work in a poster, as well as PowerPoint presentations. The surveys used in this study did not assess whether students conducting research had an effect on their interest in STEM.

Another recommendation is to incorporate more hands-on activities during STEM camps. Most students participating in this research indicated that they enjoyed the activities where they did most of the work in an active manner, such as when they went to the river, collected and tested water samples, and when the students participated in building a water filter. Students enjoyed those hands-on activities more than the passive activities such as the site visits.

A good addition to a STEM camp would be to provide an explanation of what kind of careers are there in STEM. Some students commented that they do not know what STEM professionals do, and while the camp sheds some light on a small part of STEM concerning water engineering, there is a lot more to STEM than that. Short presentations throughout the camp, discussing the various career prospects in STEM, may be helpful to students who do not know what kind of careers they could expect if they were to go into a STEM field.

Additionally, since technology was the only field where the students did not experience a significant increase in interest, it may be beneficial to have mentors who represent all of the fields of STEM. If the purpose of such camps is to increase interest in STEM as a whole, then all the fields should be represented.

An alternative methodology for this study could be to collect data from four different student groups; 1) those attending the camp, and being taught about camp
content by teachers who attended the camp, and received professional development associated with it; 2) students not attending the camp, and being taught about camp content by teachers who attended the camp, and received professional development associated with it; 3) students who attended the camp, and where taught by teachers not involved with the camp; 4) students not attending the camp, and taught by teachers not attending the camp. Having those four groups of students would allow for multiple treatments, as well as a control group, which could shed light into what has a greater effect on students during a week-long camp.

Future researchers could use these recommendations to help them design their own study and data collection methods. Additionally, the insights gained from this work could help with the design of activities, and the method in which students are recruited. Parents, teachers and students who are interested in STEM, could be asked to help recruit low-interest students to attend STEM camps. Additional, data could be collected about teachers’ involvement and influence on students’ interest.
References


for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey.


Appendices
Appendix A

Recruitment Flier
SUMMER ENGINEERING CAMP

July 10 - 14, 2017 & July 17 - 21, 2017

BUILD. EXAMINE. TEST. DISCOVER THE POWER OF WATER.

For all USU STARS! GEAR UP 8th-grade scholars transitioning into 9th grade.

Register for the free camp by April 28, 2017 at utahstars.usu.edu

Questions? Contact us at 435-797-5705 or usu.stars@usu.edu

*Utah State University will make reasonable accommodation for a disclosed physical or mental disability or a disclosed medical condition.

PARTICIPANTS WILL ALSO

- Learn from professors
- Explore aquatic life
- Kayak & paddle board
- Make new friends
Appendix B

Consent forms and Youth Assent
Informed Consent

[USU GEAR UP 2 Engineering Camp]

Introduction or Purpose

You and your child are invited to participate in a research study conducted by Dr. Kurt Becker, a Professor in the Engineering Education Department at Utah State University. The purpose of this research is to increase middle and high school students’ interest in pursuing careers in STEM (Science, Technology, Engineering and Mathematics) fields. The focus is to understand students and parents’ perceptions of STEM, and why students decide to go into those fields or to go into non-STEM fields. The goal is to understand why many students are not interested in going into those fields despite those fields having more yearly job growth, and on average, higher pay than non-STEM jobs. This information will help the researchers to design interventions to help them better understand these fields and increase students’ interest in them.

This form includes detailed information on the research to help you decide whether to let your child participate in this study. Please read it carefully and ask any questions you have before you agree to have your child participate.

Procedures

This study is part of the one-week GEAR UP STARS workshop experience your child is already participating in during July 2017. Your child’s participation will involve filling out a survey at the beginning and end of the workshop regarding interest in STEM (Science, Technology, Engineering and Mathematics). Your child will also be writing brief journals during their workshop experience. The surveys should take about 10 minutes to complete each time, and the journals should take about 5 minutes each day. If you agree to have your child participate, the researchers will also collect demographic data such as age, gender and ethnicity. We anticipate that 60 middle school students will participate in this research study.

Additionally, we would like to invite you to help us understand parents’ perspectives and perceptions about STEM careers by filling a pre workshop survey included with this informed consent form. The survey should take less than 5 minutes to fill out. During the workshop, you will be sent a link to a blog updated daily with pictures and videos taken that day of what the children are doing, a small summary of the day’s activities and some quotes from the participating children. After the workshop, you are encouraged to discuss the workshop with your child as well as fill a post workshop survey, which should also take less than 5 minutes to fill out. The information you provide will help us understand parents’ perceptions of STEM careers. It will also help us understand which parts of the workshop you and your child liked, which will help us design future workshops and studies.
Risks

This is a minimal risk research study. That means that the risks of participating are no more likely or serious than those you encounter in everyday activities. The foreseeable risks or discomforts include loss of confidentiality. The responses will be confidential and the participant names will be removed, and study ID numbers will be used instead. In order to minimize those risks and discomforts, the researchers will keep the surveys at the minimum length needed and they will be phrased clearly and should not take a lot of time. The names will also be replaced with study ID’s. If your child has a bad research-related experience or is injured in any way during his/her participation, which is extremely unlikely in this kind of study, please contact the principal investigator of this study right away at (435) 797-2076; or Kurt.Becker@usu.edu.

Benefits

Participation in this study may directly benefit your child by learning about STEM fields and choosing to pursue one of them as a future career. Those careers are often rewarding and there are plenty of job opportunities. Potential benefits for your child include increased academic knowledge and skills related to core objectives in middle school level science. Additional benefits may include an increase in team building and problem solving skills. For you, as the parents, this study will help you understand more about the workshop your child is participating in and help shape future workshops as well as understanding more about your child’s interests. More broadly, this study will help the researchers learn more about middle and high school students’ perceptions of STEM fields and may help future populations with similar issues. This study will also help future researchers design interventions to help with underrepresented populations understand STEM fields and choose them as future careers.

Specifically, filling out the surveys may enable the students to think more about their future careers, especially after participating in the workshop and being exposed to the fields of STEM. Additionally, when parents fill out the surveys and follow their child's journey in the workshop, they may have more interest to discuss STEM fields or their child's future career in general.

More broadly, this study will help the researchers gain a better understanding of students and their parents' perception of STEM and why those students may or may not choose to go into STEM fields as well as the factors involving that decision, and may help future populations with similar issues/future researchers design interventions regarding STEM interest.

Confidentiality

The researchers will make every effort to ensure that the information your child provide as part of this study remains confidential. Your identity and your child’s identity will not be revealed in any publications, presentations, or reports resulting from this research study. However, it may be possible for someone to recognize your child’s
particular story/situation/response, but is unlikely as the number of participants is large and the questions will not be specific enough for that to happen.

We will collect data through Surveys using Qualtrics as well as written journals. This information or data will be securely stored in a restricted-access folder on Box.com, an encrypted, cloud-based storage system which is USU’s recommendation for all digital content. The identifiers and data will be kept for seven years, which is the requirement of the Department of Education. Any hard copies of surveys or journals will be transcribed and moved to the same encrypted database and the hard copies will be destroyed.

It is unlikely, but possible, that others (Utah State University, [funding sponsor; The Department of Education] or state or federal officials) may require us to share the information you give us from the study to ensure that the research was conducted safely and appropriately. We will only share your child’s information if law or policy requires us to do so. If the researchers learn that your child is abusing/neglecting going to engage in self harm/intend to harm another, state law requires that the researchers report this behavior/intention to the authorities.

The research team works to ensure confidentiality to the degree permitted by technology. It is possible, although unlikely, that unauthorized individuals could gain access to your responses because you are responding online. However, your participation in this online survey involves risks similar to a person's everyday use of the Internet.

Voluntary Participation, Withdrawal [and Costs]
You and your child’s participation in this research is completely voluntary. If you agree to let your child participate now and change your mind later, you may withdraw your child at any time by contacting the project PI (Dr. Kurt Becker) to have your child be withdrawn from the study. If you choose to withdraw your child after we have already collected information from your child, the information will be destroyed and not used as part of the study. If the participant is already or may in the future receive services from the GEAR UP Project, if you decide to not have your child participate, the services your child receive from the GEAR UP Project will not be affected in any way.

The researchers may choose to terminate your participation in this research study through withdrawal by the students, absenteeism from a majority of the activities, or missing data and you will be informed in writing.

IRB Review
The Institutional Review Board (IRB) for the protection of human research participants at Utah State University has reviewed and approved this study. If you have questions about the research study itself, please contact the Principal Investigator at (435) 797-2076 or Kurt.Becker@usu.edu. If you have questions about your child’s rights or would simply like to speak with someone other than the research team about questions or concerns, please contact the IRB Director at (435) 797-0567 or irb@usu.edu.

Please affix an electronic signature
Informed Consent

By signing below, you agree to let your child participate in this study. You indicate that you understand the risks and benefits of participation, and that you know what your child will be asked to do. You also agree that you have asked any questions you might have, and are clear on how to stop your child’s participation in the study if you choose to do so. Please be sure to retain a copy of this form for your records.

__________________________  ______________________  ______
Parent’s Signature          Parent’s Name, Printed   Date
**Youth Assent**

We are doing a research study to understand why middle and high school students choose to go into STEM (Science, Technology, Engineering and Mathematics) fields. Research studies help us learn more about people. If you would like to be a part of this research study, you will help us understand what students think about STEM fields by filling out a survey at the beginning and end of the GEAR UP workshop you are participating in in July. The surveys will be about your interest in STEM (Science, Technology, Engineering and Mathematics). You will also be writing brief journals during the workshop. The surveys should take about 5-10 minutes to complete each time, and the journals should take about 5 minutes each day.

If you participate in this study, there are some things that may be good for you. Those things include finding an interest in STEM fields, following a career in one of those fields which can be very rewarding, and there are always career opportunities in those fields. Other benefits include increased knowledge and skills related to middle school level science and an increase in team work and problem solving skills. Also, filling out the surveys may help you to think more about your future career, especially after participating in the workshop and being exposed to the fields of STEM.

If this sounds like something you would like to do, we will ask you to say that you understand what we talked about, and that you do want to participate. You do not have to be in this study if you do not want to be. If you decide to stop after we begin, contact Dr. Kurt Becker at Kurt.Becker@usu.edu or tell the teacher you came with to the workshop and tell them that you would like to drop out of the data collection part of the workshop. You can still attend the workshop if you want, but you do not have to respond to the surveys. If any data has been collected from you, we can delete that data. No one will be upset if you don't want to do this, or change your mind later.

You can ask any questions you have, now or later. Your parents know about this research study, and they have said you can participate, if you want.

If you would like to be in this study, please sign your name and write the date.

________________________               ______________________
Name                                                      Date
Appendix C

Students’ Survey Instrument
We would like to thank you for participating in the GEAR UP engineering camp.

Please answer the following questions about yourself:

Name (First and last):

Age:

Gender:
- Male
- Female

Ethnicity:
- White
- Black or African American
- American Indian or Alaska Native
- Asian
- Native Hawaiian or Pacific Islander
- Hispanic
- Other

School:

How many STEM (Science, Technology, Engineering and Mathematics) camps have you participated in including this one? (The camp must be multiple-day)
- None
- 1-2 camps
- 3+ camps
Which of the activities listed below have you participated in in the past year? (You can choose more than one)

- [ ] Science Fair
- [ ] Visit to a Science center/museum, zoo or aquarium
- [ ] STEM workshop or engineering camp
- [ ] STEM Competition
- [ ] STEM professional visited your school
- [ ] After school STEM club
- [ ] Other (Please specify in the space below)

If you chose other in the previous question, please specify what kind of activity.

[ ]

When was the first time you participated in the STEM activities in the previous questions?

- [ ] Before elementary school
- [ ] During elementary school
- [ ] During middle school

Each question is a Likert scale with the following choices: Strongly Disagree , Disagree, Neither Agree nor Disagree, Agree, Strongly Agree

The following questions pertain to your friends' attitudes towards Science:

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Somewhat agree</th>
<th>Neither agree nor disagree</th>
<th>Somewhat disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>My best friend likes science</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>My best friends in class like science</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>My friends like science</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Most of my friends do well in science</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Name in order the three biggest influences on your choice of career in the future.

[ ]
Each question is a Likert scale with the following choices: Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree.

The following questions pertain to your experience with *Science*:

<table>
<thead>
<tr>
<th>I am able to get a good grade in my <em>science</em> class.</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am able to complete my <em>science</em> homework.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I plan to use <em>science</em> in my future career.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I will work hard in my <em>science</em> classes.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>If I do well in <em>science</em> classes, it will help me in my future career.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>My parents would like it if I choose a <em>science</em> career.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am interested in careers that use <em>science</em>.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I like my <em>science</em> class.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I have a role model in a <em>science</em> career.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I would feel comfortable talking to people who work in <em>science</em> careers.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I know of someone in my family who uses <em>science</em> in their career.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
The following questions pertain to your experience with *Mathematics*:

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am able to get a good grade in my <em>mathematics</em> class.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I am able to complete my <em>mathematics</em> homework.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I plan to use <em>mathematics</em> in my future career.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I will work hard in my <em>mathematics</em> classes.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>If I do well in <em>mathematics</em> classes, it will help me in my future career.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>My parents would like it if I choose a <em>mathematics</em> career.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I am interested in careers that use <em>mathematics</em>.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I like my <em>mathematics</em> class.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I have a role model in a <em>mathematics</em> career.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I would feel comfortable talking to people who work in <em>mathematics</em> careers.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>I know of someone in my family who uses <em>mathematics</em> in their career.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
The following questions pertain to your experience with **Technology**:

<table>
<thead>
<tr>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am able to do well in activities that involve <strong>technology</strong>.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am able to learn new <strong>technologies</strong>.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I plan to use <strong>technology</strong> in my future career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I will learn about new <strong>technologies</strong> that will help me with school.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If I learn a lot about <strong>technology</strong>, I will be able to do lots of different types of careers.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When I use <strong>technology</strong> in school, I am able to get better grades.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am interested in careers that use <strong>technology</strong>.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like to use <strong>technology</strong> for class work.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have a role model who uses <strong>technology</strong> in their career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would feel comfortable talking to people who work in <strong>technology</strong> careers.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I know of someone in my family who uses <strong>technology</strong> in their career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The following questions pertain to your experience with **Engineering**:

<table>
<thead>
<tr>
<th>I am able to do well in activities that involve <strong>Engineering</strong>.</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am able to complete activities that involve <strong>Engineering</strong>.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I plan to use <strong>Engineering</strong> in my future career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I will work hard on activities at school that involve <strong>Engineering</strong>.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If I learn a lot about <strong>Engineering</strong>, I will be able to do lots of different types of careers.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My parents would like it if I choose an <strong>Engineering</strong> career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am interested in careers that involve <strong>Engineering</strong>.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like activities that involve <strong>Engineering</strong>.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have a role model in an <strong>Engineering</strong> career.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I would feel comfortable talking to people who are <strong>Engineers</strong>.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I know of someone in my family who is an <strong>Engineer</strong>.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
I would like you to write about your experience with STEM (Science, Technology, Engineering and Mathematics) fields.

Are you interested in a STEM (Science, Technology, Engineering and Mathematics) career? Why or why not?

(This question will only be in the post-survey) How did the workshop affect your choice of career for the future?

- Reinforced my choice
- Changed my choice to a STEM career
- Changed my choice to a non-STEM career
- No influence on my decision
- Made me more confused
Appendix D

Parents’ Survey Instrument
Thank you for sending your child to the USTAR SUMMER workshop.

Please take a few minutes to fill out this survey and help us understand parental perceptions about STEM careers (Science, Technology, Engineering and Mathematics).

What is the name of your child that participated in the workshop?

Are you the father or mother?
- [ ] Father
- [ ] Mother

What is your highest level of education?
- [ ] Less than high school
- [ ] High school graduate
- [ ] Associate's degree
- [ ] Bachelor's degree
- [ ] Graduate degree
- [ ] Other

What is your job or occupation?

What is your yearly household income?
- [ ] Less than $20,000
- [ ] $20,000 - $30,000
- [ ] $30,000 - $40,000
- [ ] $40,000 - $50,000
- [ ] $50,000 - $70,000
- [ ] $70,000 - $100,000
- [ ] $100,000 - $150,000
- [ ] $150,000 - $200,000
- [ ] $200,000 or more

On a scale of 5 to 1, with 5 being really important, how important are the following characteristics for your child in order for the child to be successful in what he/she will be doing when he/she grows up?

**Math**
- [ ] 5 (Really important)
- [ ] 4
- [ ] 3
- [ ] 2
- [ ] 1 (Not important at all)

**Science**
- [ ] 5 (Really important)
- [ ] 4
- [ ] 3
- [ ] 2
- [ ] 1 (Not important at all)

On a scale of 5 to 1, with 5 being really important, how important are the following characteristics for your child in order for the child to be successful in what he/she will be doing when he/she grows up?

**Science**
- [ ] 5 (Really important)
- [ ] 4
- [ ] 3
- [ ] 2
- [ ] 1 (Not important at all)

Which of the following careers, if any, would you like your child to pursue? What is the following. If any, do you think your child will want to pursue?

- [ ] Scientist
- [ ] Engineer
- [ ] Physician/Doctor
- [ ] Professional/Other
- [ ] Computer
- [ ] Scientist
- [ ] Mathematician
- [ ] Other professional
- [ ] Teacher
- [ ] Entrepreneur
- [ ] Business/Entrepreneur
- [ ] Artist/Designer
- [ ] Military/Other
- [ ] Professional/Other
- [ ] No Preference/Don't Know

Please answer the following questions about your attitudes towards engineering:

- [ ] I believe engineering improves our quality of life
- [ ] I enjoy my job/hobbies or pursue a career in engineering
- [ ] I think it is more important for girls to learn engineering than it is for boys to learn engineering
- [ ] I think it is more important for boys to learn engineering than it is for girls to learn engineering
- [ ] I think it is equally important for both boys and girls to learn engineering

What are your thoughts on the importance of USTAR (Science, Technology, Engineering and Mathematics) for the future of your family?
Appendix E

Daily Journal Prompt
**Reflection and Feedback Form**

<table>
<thead>
<tr>
<th>What have you learned today?</th>
<th>What would you tell a friend about today’s session?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Before today I thought…</th>
<th>But now I think…</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Which of today’s activities affected your thinking about STEM (Science, Technology, Engineering and Mathematics) fields? How did it change?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
Appendix F

Curriculum Vitae
Murad Musa Mahmoud  
1355 N 800 E Apartment 10E, Logan, Utah  
435-799-7256  
Murad.Mahmoud@USU.edu

### Education

**Utah State University**, College of Engineering.  
Department of Engineering Education.  
Degree: **Ph.D.**  
Graduation Date: May 2018  
GPA: **3.96/4.00**

**Dissertation:** “Attracting Secondary Students to STEM Using a Summer Engineering Workshop”. The research investigates students who attend an engineering/STEM summer camp, and their interest in pursuing STEM fields.

**The University of Jordan**, Faculty of Engineering and Technology.  
Mechanical Engineering Department.  
Degree: **Masters**  
Graduation Date: May 2011  
GPA: **3.22/4.00**

**Thesis:** “Analysis of a Hybrid PV- Solar Thermal Collector with Built-in Water Desalination System”. The analysis included establishing a mathematical model for the system and using MATLAB to predict its behavior and the effect of various parameters on its performance. The other component was building an experimental rig and test its performance and to compare the theoretical with the experimental results.

**The University of Jordan**, Faculty of Engineering and Technology.  
Mechanical Engineering Department.  
Degree: **B.Sc.**  
Graduation Date: August 2007  
GPA: **3.13/4.00** (Finished all the credit hours for engineering in four years instead of five).  

**Highest grade in class in the ETS (Educational Testing Services) qualification exam** (similar to the FE exam).  
**Graduation/Capstone Project:** “Aircraft Air-Conditioning System”.

Class Rank (Tawjihi): **92.2%**
Teaching Experience

**Teaching and Research Assistant: Utah State University**, January 2015 to Present. Logan, Utah, USA.

*Named the Graduate Student Teacher of the year award; sustained “excellent” teaching evaluation with an average student evaluation of around 95%.*

- Helped teach the **Computer Engineering Drawing** course using AutoCAD software. The course content was delivered in hybrid format with both synchronous and asynchronous components.
- Developed and delivered all the lectures in the second half of the semester covering 3D modeling.
- Participated in teaching this course over the period of 6 semesters for over 400 students from the Biological, Civil, and Environmental engineering disciplines.
- Developed curriculum for the Computer Engineering Drawing course by creating over 20 new assignments.
- Developed five 3D printed demonstrations for concepts that were difficult in the Dynamics course. Those concepts included: Projectile Motion, Tangential/Normal Velocity and Acceleration and Vectors.

**Lecturer: The German Jordanian University**, June 2012 to January 2015. Amman, Jordan.

*Won 2 letters of recognition for Excellence in Teaching and maintained an “excellent” teaching evaluation with an average of around 90%.*

Taught 18 credits in the spring and fall semesters in addition to 9 credits in the summer.

- **Curriculum development:** Created new syllabi, lecture materials, assignments and assessments for the courses Computer-Aided Engineering Drawing, Statics and Dynamics and Engineering Economics.
- **Course Coordination:** Coordinated between multiple instructors and teaching assistants for the Computer-Aided Engineering Drawing course and the Statics and Dynamics combined course.
- **Mentoring and Advising:** Worked one-on-one with students during office hours. This included helping students struggling with course material or mentoring students on topics such as courses to take, graduate school, potential careers, and other issues as needed.
### Undergraduate Courses Taught:

<table>
<thead>
<tr>
<th>Course</th>
<th>Number of Semesters</th>
<th>Number of Students</th>
<th>Students’ Majors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer-Aided Engineering Drawing; Manual Drafting and using AutoCAD software</td>
<td>8</td>
<td>700</td>
<td>Biological, Civil &amp; Environmental, Energy, Industrial, Mechanical &amp; Maintenance, Mechatronics, and Pharmaceutical-Chemical Engineering.</td>
</tr>
<tr>
<td>Statics and Dynamics (Combined Course)</td>
<td>3</td>
<td>120</td>
<td>Industrial, Biological, Environmental, and Mechatronics Engineering.</td>
</tr>
<tr>
<td>Statics</td>
<td>1</td>
<td>25</td>
<td>Mechanical &amp; Maintenance Engineering.</td>
</tr>
<tr>
<td>Engineering Economics</td>
<td>1</td>
<td>70</td>
<td>Biological, Civil &amp; Environmental, Energy, Industrial, Mechanical &amp; Maintenance, Mechatronics, and Pharmaceutical-Chemical Engineering.</td>
</tr>
<tr>
<td>Machine Design Lab using CATIA software</td>
<td>1</td>
<td>20</td>
<td>Mechanical &amp; Maintenance, and Mechatronics Engineering.</td>
</tr>
</tbody>
</table>

**Part-time Instructor/Graduate Teaching and Research Assistant The University of Jordan:** September 2008 to August 2012, Amman, Jordan.

Volunteered to lead recitation sessions before the midterm and final exams for the course Engineering Drawing and Descriptive Geometry. Those sessions often had an attendance of 50 – 100 students.

### Undergraduate Courses Taught:

<table>
<thead>
<tr>
<th>Course</th>
<th>Number of Semesters</th>
<th>Number of Students</th>
<th>Students’ Majors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering Drawing and Descriptive Geometry; Manual Drafting and using AutoCAD</td>
<td>5</td>
<td>1000</td>
<td>Architecture, Chemical, Civil, Computer, Electrical, Industrial, Mechanical, and Mechatronics Engineering</td>
</tr>
<tr>
<td>Programming for Engineers using MATLAB software</td>
<td>1</td>
<td>35</td>
<td>Mechanical Engineering.</td>
</tr>
<tr>
<td>Strength of Materials Lab</td>
<td>2</td>
<td>50</td>
<td>Mechanical Engineering.</td>
</tr>
<tr>
<td>Technical Writing</td>
<td>1</td>
<td>150</td>
<td>Architecture, Chemical, Civil, Computer, Electrical, Industrial, Mechanical and, Mechatronics Engineering.</td>
</tr>
</tbody>
</table>
Grader for the courses:
- Dynamics
- Strength of Materials
- Engineering Mechanics (Statics and Dynamics)
- Heat Transfer
- Thermal and Fluid Sciences
- Strength of Materials

Research Experience

Teaching and research Assistant: Utah State University, January 2015 to Present. Logan, Utah, USA.

- Conducted Engineering Education research as part of USU GEAR UP STARS (Utah State University Science Technology Arithmetic Reading Students Gaining Early Awareness and Readiness for Undergraduate Programs) program, a seven-year project funded by the Department of Education with a budget of over $30 million.
- Participated in data collection for two outreach engineering summer camps to increase the participating students’ interest in STEM fields. Worked with faculty and undergraduate student researchers to deliver and evaluate the camps.

- The focus of the project was on diversity and traditionally underrepresented groups in the fields of STEM.
- Developed curriculum for the course Computer Engineering Drawing with the help of faculty and undergraduate student researchers by creating over 20 new assignments. Previous assignments were mostly mechanical engineering-based while the students taking the course were from the Biological, Civil and Environmental engineering departments. The new assignments developed were based on those disciplines and more relevant to the students taking the course.

- The students appreciated the new and more relevant assignments as shown by surveys they filled on a weekly basis.

- Results from the first two semesters were published in a conference paper; results from the remaining semesters is currently being written into a journal paper.


- Worked on writing five proposals in the energy sector.
- Helped mentor 3 undergraduate and graduate exchange students.
Service


- Participated in the American Society of Engineering Education annual conference in 2016 and 2017 and helped with the booth for Utah State University whether for recruiting and giving information to students or answering questions about the university and the department from conference attendees.

- Participated in a recruiting trip for the department of Engineering Education. The trip was to Boise State University and it was successful and attracted one student to the program.

- Jointly hosted a talk as part of the spring of 2017 research seminar to help upcoming and junior graduate students in the department navigate through and succeed in the program.

- Will participate in January, 2018 in a project to create videos to help upcoming international students succeed as teaching assistants at Utah State University.

- Guest speaker in the listening class for international students at Utah State University. Topic: Calculating the payback period of a renewable energy system.

Industry Experience


- Worked on projects including the German Jordanian University, Detainee Building in Abu Dhabi, Jeneen Hospital and Sana’a hospital in Yemen.
- Designed HVAC (Heating, Ventilation and Air Conditioning), water, drainage and firefighting systems for buildings.


- Training in on-site supervision, building design and consulting.

Publications


Publications in Progress:


Mahmoud, M., Becker, K., (2018) Computer Aided Engineering Drawing: A look at a Hybrid Teaching Model. This is a continuation on the conference paper regarding the new teaching model. This paper covers four semesters worth of data collected about student satisfaction with the various course components and the new assignments created based on their disciplines as well as their grades compared to the previous years when the assignments were not discipline-based. Paper will be submitted to The Engineering Design Graphics Journal in 2018.

Mahmoud, M., Becker, K., (2018) Attracting Secondary Students to STEM Using a Summer Engineering Camp. This paper is going to be based on the dissertation research being conducted currently to get more students into STEM. Paper will be submitted to the Journal of STEM Education in the spring of 2018.

Awards and Achievements

- **Graduate Student Teacher of the Year**: Utah State University, Department of Engineering Education, 2015.
- **Excellence in teaching award**: the German Jordanian University, 2014.
- **Excellence in teaching award**: the German Jordanian University, 2013.
- Passed the International Teaching Assistant Seminar in the summer of 2015 at Utah State University and was recommended for classroom teaching by the professor giving the seminar.
- Passed TOEFL IBT test with 115/120 total score.
- Passed GRE general test with a score of 164 in the quantitative reasoning part (88 percentile), 149 in the verbal reasoning part and 4.5 in the analytical writing (80 percentile).
Languages and Computer Skills

Languages:

Arabic (Native Language): Fluent in reading, writing and speaking.
English: Fluent in reading, writing and speaking.
French: Beginner
German: Beginner

Interpersonal Skills: The ability to build good relationships with colleagues and strong rapport with students.

Computer Skills

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<td>Windows and Microsoft Office Word, Excel, and Power Point</td>
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