An Investigation of the Impact Gender-Specific Course Grouping Has on Female Middle-School Students' Concept of and Interests Toward Technology and Engineering

Thomas Broderick Walsh
Brigham Young University

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An Investigation of the Impact Gender-Specific Course Grouping Has on Female Middle-School Students’ Concept of and Interests Toward Technology and Engineering

Thomas Broderick Walsh

A thesis submitted to the faculty of Brigham Young University in partial fulfillment of the requirements for the degree of Master of Science

Steven L. Shumway, Chair
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ABSTRACT

An Investigation of the Impact Gender-Specific Course Grouping Has on Female Middle-School Students’ Concept of and Interests Toward Technology and Engineering

Thomas Broderick Walsh
School of Technology, BYU
Master of Science

Attempts to improve retention, interest, and enrollment of females in Technology & Engineering Education courses have included a variety of approaches including female-only classes. However, the implications of such courses have not been thoroughly investigated. Therefore, an investigation of female-only classes was undertaken; the findings revealed that the overall enrollment of females went up in the course and in subsequent classes, these students maintained their interests and attitudes towards Technology and Engineering, their perceptions of an engineer’s gender changed from that of mostly male to mostly female, and their concepts of what an engineer does changed from mostly building or fixing things to that of mostly someone who designs. This study used two instruments: the Technology Engineering Attitude Survey (TEAS) and the Draw an Engineer Test (DAET). The population of the study was 7th grade middle school students. They were placed into two groups: the control being the mixed male female engineering and technology classes, and the treatment being the all-female students enrolled in the same engineering technology course.

Keywords: technology, engineering, female, women, girls, male, men, boys, technology engineering attitude survey, teas, draw an engineer test, daet, technology and engineering, engineering and technology, education, technology and engineering education, science technology engineering math, stem, science technology engineering art math, steam, non-traditional careers, women in engineering, k-12, middle School, junior high, public school, utah, usa, industrial education, vocational education, stem education, steam education, teaching
ACKNOWLEDGEMENTS

I would like to thank my professors and committee who worked with me in completing this paper. I would like to especially thank Dr. Kip Christensen who began on my committee and then retired and wish him all the best in retirement. I would like to thank my friends and family for their love and support: Mindy Walsh, Victor Walsh, Andrew Walsh, Hayden Faas, Caroline Hilton, Sterling Hilton, Tyler Sayre, Bob Aiman, Rachel Adams, Monica Earl, Gregg Olsen, and Blake Hoover. I would like to especially thank my fiancée, Katie Gerrard, for always encouraging me and supporting me through this entire process. Thank you for all that came before and wrote their wonderful article in which I could draw upon for my thesis. I would also like to acknowledge my Heavenly Father and His son Jesus Christ.
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1 INTRODUCTION

1.1 Nature of the Problem

There is a current need for Science, Technology, Engineering and Mathematics (STEM) professionals to meet the demands of an ever-increasing technology-dependent society. This is especially true for minorities and females which have traditionally been under-represented in STEM-related professions (Rocheleau, 2016). For example, in the engineering profession (The “E” of STEM), despite the many efforts to increase the number of female students pursuing STEM-related degrees, the U.S. Department of Education (2014) reports that female participation at all degree levels and in all STEM disciplines, including engineering, continues to remain well below that of males.

Researchers and education professionals have put forth much effort to try and identify and address the underlying issues related to why there are lower percentages of females choosing engineering-related majors. Verdín, et al. (2018) proposed that the social norms related to the engineering climate often affects students’ perceptions of inclusivity which may explain some of the lower percentages of female students choosing engineering majors. Reinking and Martin (2018) comment that if stereotypes and mindsets are changed, there could be a significant increase in girls’ sense of belonging in professions such as engineering. Others, such as (Leaper, 2014; and Partridge et al., 2008) conducted supporting research on gendered socialization in
which outside factors including parents, courses, teachers, and society, influence student choices and that females have not traditionally been encouraged to pursue engineering for a major.

1.1.1 Peer Groups

Others propose that the gender gap in professions such as engineering, is directly linked to the role peer groups play in the academic experiences of students (Crosnoe et al., 2008). According to these authors, “students, especially those in adolescence, enjoy being part of a peer group and would rather engage in similar activities as their peer groups than engage in activities that may not coincide with the ‘in group’ perception from their peers’ point of view”. You (2011) found “that peers have an important influence on the behavior and development of adolescents” and that “the child’s acceptance within the peer group is one of the key measures of positive/negative school experiences”. While their research was not specifically related to engineering, Leaper et al. (2012), found that girls’ motivation in math and science courses during the adolescent years is positively associated with peer support. In summary, one way educators might engage in changing gender stereotypes and enable increased levels of females engaging in engineering-related studies is by providing positive peer group experiences.

Given that middle school student interest in technology has been found to be positively correlated with participation in engineering and technology activities (Cook, 2009), one possible way to increase female student interest in technology and engineering is to enable them to have a more positive peer group experience with these subjects during their formative years. This notion is supported in an article published by CNN (Parke, 2014) in which experts comment that “A huge part of the reason women are not entering these STEM-related fields, and a huge part of the
solution starts at the very beginning” with “this beginning” including positive peer experiences in science, technology, engineering and math for females during adolescence.

To address the issue of helping female students feel more comfortable with the opportunity of taking Career and Technical (CTE) classes that include technology and engineering related content, the Alpine School District recently provided female middle school students with an opportunity to sign up for an all-female Exploring Technology Class offered to all 7th grade students to provide for a similar peer group socialization. In this class, middle school students are provided with technology and engineering design activities that include, manufacturing, robotics, electronics, and other related activities. Female students are allowed to sign up for the course in mixed male-female classes or in all female classes. The underlying problem is that there has been no research conducted to see if participation in these peer group situations has a positive impact on female students' perceptions of engineering.

1.2 Purpose of the Research

The purpose of this study was to investigate potential changes in female students’ concept of, and interest toward, technology and engineering. Specifically, we investigated female students enrolled in an all-female middle school technology and engineering class.
2 REVIEW OF THE LITERATURE

2.1 Underrepresentation of Women in Engineering

As early as the 1960’s, the President's Commission on the Status of Women emphasized the need for women to pursue education in science and engineering careers to meet the needs of an ever-increasing technological society (Rossi, 1965). Despite this emphasis, historically, women in the United States have been represented at lower rates than men in both science and engineering degree programs and careers (Rocheleau, 2016; SWE Website; Rincon, 2018; National Center for Education Statistics, 2014). According to Schilling and Pinnell (2019), the initial lack of representation started early in the last century because females did not attend college or university with the frequency of males. However, despite a current equalization of the percentage of males and females attending colleges and universities, the percentage of engineering majors was still unequal, with males greatly outnumbered females.

On the Society of Women in Engineering (SWE) website database, Rincon (2018), Manager of Research for SWE, reports, while over time the data shows more females entering STEM occupations, this increase has mostly been in the life sciences while women in computer science and engineering fields have had little increase. The data presented in Figure 1, shows the current percentage of women in engineering to be around 13%, a percentage which has grown only slightly in the last decade.
Related to this, research statistics that indicate that fewer bachelor’s degrees have been awarded to females when compared to males. Note from the graph in Figure 2, that while the
number of degrees in engineering and computer science has steadily increased, the percentage of females receiving these degrees continues to be less than 20%.

2.2 Possible Causes of Underrepresentation of Women in Engineering

Researchers and education professionals have put forth much effort to try and identify and address the underlying issues related to why there are lower percentages of females choosing engineering-related majors. According to Stockwell (2017), some of the leading theories as to why a lower representation of females choose engineering include: the perception of the engineering profession as masculine, the need for positive female role models in engineering, and the thought that introductory engineering-related classes need to be redesigned to be more welcoming to female students.

In terms of lack of mentorship, Parke (2014), reports that only 4% of girls who are wanting a STEM-related career, have a mentor to encourage them. She proposes that one of the ways to encourage girls to pursue STEM-related careers such as engineering, is through early exposure to content, and by finding mentors in a related field. Reinking and Martin (2018) agree with Parke in the idea that exposure is good for closing the gender gap in STEM disciplines such as engineering. From their research they have found that mentors, including teachers, can provide experiences to help “expose children to female role models, create hands-on, safe environments for exploration, and combat societal gender stereotypes.”

Others (Crosnoe et al., 2008) propose the gender gap in any STEM discipline is directly linked to the role peer groups play in the academic experiences of students. According to these authors, students, especially those in adolescence, enjoy being part of a peer group and would rather engage in similar activities as their peer groups than engage in activities that may not
coincide with the “in group” perception from their peers’ point of view. Reinking and Martin (2018) provide additional support to this peer group theory by reporting on their research that found that middle school aged children are especially influenced by their peers because of the stage they are at in their adolescent development. Additionally, You (2011, p. 835) found “that peers have an important influence on the behavior and development of adolescents” and that “the child’s acceptance within the peer group is one of the key measures of positive/negative school experiences”. While their research was not specifically related to engineering, Leaper et al. (2012), found that girls’ motivation in math and science courses during the adolescent years is positively associated with peer support. In summary, one way educators might engage in changing gender stereotypes and enable increased levels of females to engage in engineering-related studies is by providing positive peer group experiences.

2.3 History of Technology and Engineering Education

Given that this research study will be conducted in a middle school Technology and Engineering Education (TEE) classroom as part of the State of Utah course offerings for Career and Technical Education (CTE), a brief history on the philosophical underpinnings of the profession is presented in this section. The Technology and Engineering Education profession gets much of its philosophical roots from Johann Heinrich Pestalozzi who was born in Switzerland in 1746 (Bennett, 1926). Pestalozzi, influenced by the writings of Rousseau and his philosophies of education according to experience and nature, had a desire to improve society through education and developed a precursor to free public education by taking orphans and other children off the street, giving them a place to live, and forming a school. Pestalozzi and associates became the master teachers and taught the children to read and write and perform math operations using manual labor and the development of a useful trade the children could use
in their future lives so that they might rise above their circumstances. Pestalozzi later aided in starting many schools that taught people to work with their hands. Educators came from all around the world to see these Pestalozzian schools and to implement his techniques and philosophies in their schools. Over the years these philosophies of manual arts and training progressed into the Industrial Arts.

Industrial Arts (IA), as an important component of public general education, started around the early 1900’s and primarily focused on the subjects of drafting, woodworking, and metalworking (Barlow, 1967). In 1947, William Warner, a professor at Ohio State University and a leader in the IA profession presented a new curriculum to reflect technology to the profession in which he proposed that the emphases and philosophies of communication, manufacturing, construction, power, transportation, and personal management be added to the curriculum of every industrial arts classroom. This philosophical change took several decades to happen and eventually led to the transition from Industrial Arts to Technology Education as an important component of general education in public schools.

In 2010, engineering concepts, especially that of having students engage in designing solutions using an engineering design process, emerged and Technology Education became Technology and Engineering Education (TEE). Between 2001 and 2004, Dr. Ramaley of the National Science Foundation introduced the acronym, STEM, with the T and the E of STEM being Technology and Engineering and helped bring this new education emphasis into popularity (Chute, 2009). Technology and Engineering Education falls under the current Career and Technical Education (CTE) umbrella in the State of Utah and TEE courses can be seen in many schools throughout the nation. Many high schools have strong STEM programs through technology and engineering departments. In Utah, it is required for every seventh-grade student
to take an introductory course in CTE (USBE, 2019). Utah students then have the opportunity to pursue technology and engineering classes throughout their middle school and high school years.

2.4 Development of the Technology and Engineering Attitude Survey (TEAS)

Technology and Engineering courses offered at the middle school level have changed dramatically over the last 40 years and so have the associated assessments that have explored student interest in and perceptions of technology. The Technology and Engineering Attitude Scale (TEAS) was developed by Keri Cook in 2009 in response to adding engineering content to the general technology education course offerings at the middle and high school levels (Cook, 2009). To develop the TEAS, Cook took the Technology Attitude Scale (TAS) created in 1993 by Thomas Jeffrey at Virginia Tech University (Jeffrey, 1993) and modified it to include questions regarding student concepts of and interest in engineering to stay up to date with current standards of technology and engineering education (Cook, 2009). A summary of the development of various instruments used to investigate middle school students' concept of and attitudes toward technology and engineering is presented below.

The origins of the TAS and TEAS started in the 1980’s with a survey instrument entitled the Pupil's Attitudes Toward Technology (PATT). Falco de Klerk Wolters developed the PATT in the Netherlands in the 1980’s in an attempt to investigate what students in the Netherlands concepts and attitudes of technology and science were and what variables affected these attitudes (Raat et al., 1985). Because middle school is an important time for the development of attitudes, Wolters focused his research on students between the ages of ten to twelve years old. One of the underlying purposes of developing the PATT was to give students a voice in the curriculum. Wolters felt that it was important that we consider the attitudes of these students to help tailor
instruction in middle school technology courses. He used this assessment on approximately 50,000 students at 60 different schools.

Among the student attitudes toward technology and science Wolters investigated included gender differences between male and female students and their concepts and attitudes toward technology. This is evident by the types of questions he asked as some were focused on male and female stereotypes. In the end he discovered that boys tended to have a stronger interest in technology than girls did (Raat et al., 1985). This assessment was well used and tested in the Netherlands and included levels of reliability of 0.8 and greater (Wolters, 1989).

Many researchers in the United States were interested in using the PATT but it was impractical because it was not in English. In 1988, Allen Bame and William Dugger, Technology Educators from Virginia Tech University, collaborated with Marc deVries, from the University of Eindhoven in the Netherlands and converted the PATT from Dutch into English for use with middle school students in the United States (Bame & Dugger Jr, 1989). Bame and Dugger tested the English Pupil’s Attitudes Towards Technology (PATT-USA) in several middle schools in Virginia for validity and reliability (Bame & Dugger Jr, 1989). They also looked at many factors as to gender differences and why they might affect students’ concepts of and attitudes toward technology.

Peit Ankiewicz brings up some problems with the PATT-USA in that some of the questions are negatively worded, the length of the survey has proven difficult for some students, and it includes a Likert scale that uses a neutral or middle category that has proven problematic in some studies (Ankiewicz, 2019). Given these problems, some felt further refinement of the PATT-USA was needed.
In 1993, Thomas Jeffery was trying to help teachers in the United States of America find out what their students' concept of technology was. He took the work of Bame and Dugger and modified it calling it the Technology Attitude Survey (TAS). Technology has many different and broad definitions. Through the TAS, teachers can better understand what their students are thinking and adapt instruction to build on prior knowledge or to help modify or mold the curriculum to help all students understand what technology really is. The TAS was used for since 1993 in accomplishing this goal. McFarlane, et al. (McFarlane et al., 1997), used the TAS in a study that confirmed its validity. Nancy Males used the TAS in studying students with lower socioeconomic status (Males, 2011). Rebecca Loboschefsksy used the TAS to study teachers’ attitudes toward technology in 2016 (Loboschefsksy, 2016).

In the 2000’s, under the leadership of the International Technology Education Association (ITEA), engineering concepts were added to the Technology Education Profession and ITEA became the ITEEA (International Technology and Engineering Education Association) (STEM News, 2010). Keri Cook, a graduate student with interest in conducting research related to middle school female students’ interests in engineering noticed this and decided to update the TAS to include engineering terminology. She added engineering into the TAS calling it the Technology and Engineering Attitude Survey (TEAS) (Cook, 2009). She then took the new TEAS with the added engineering content and tested it with several middle schools in Utah and compiled and tested the results.

2.5 TEAS-Related Research Studies

The TEAS has been used in many studies since it’s development in 2009 (Bates, 2016; Cook, 2009; Olsen, In Press; Wright, 2018). The TEAS was first used in the study done by Keri
Cook (Cook, 2009). In her research she found that male and female student perceptions of gender appropriateness seemed to be biased according to the gender of the teacher (Cook, 2009). Meaning if the female students had a female teacher, they were more likely to see females in the roles of technology and engineering as opposed to their female counterparts with male teachers (Cook, 2009). The reverse is also true if male students have male teacher, they see technology and engineering as a male activity.

Bates used the TEAS to study male and female student’s concept of and attitudes toward engineering while participating in an underwater robotics activity (Bates, 2016). He discovered that male students were more interested initially in engineering than the female students. However, he did discover that the female student’s interest grew after participation in the engineering related underwater robotics activity.

Wright conducted a study using the TEAS to investigate the attitudes of students in a high school English classroom (Wright, 2018). His treatment included having the students read two fictional books that dealt with engineering concepts. He found that after the students read the books there was no statistical difference that occurred in the attitudes of students about technology and engineering.

A more recent study that used the TEAS was one done by Olsen (Olsen, In Press). He had 6th grade students participate in a STEM electric bicycle building activity and used the TEAS before and after to assess the attitudes of the students. By using the TEAS, Olsen concluded that the students who participated in the STEM activity had increased positive attitudes and perceptions of engineering.
Typical uses of the TEAS include investigating students’ attitudes toward engineering including, gender biases and stereotypes that students have. It has also been used to see if students have a more positive attitude toward STEM and gender stereotypes after participating in Technology and Engineering activities, clubs, and courses. A component of the TEAS has four questions that deal specifically with gender. They look at knowledge, careers, skills, and overall stereotypes of males and females (Cook, 2009). The TEAS also looks at student connections with school, their futures and many other aspects of education.

The TEAS is intended to be given to students at the beginning and at the end of the treatment. This gives the researcher baseline data and a point to compare the final data with. It is specially identified for middle school age students who are learning about and enrolled in a Technology and Engineering.

2.6 Draw an Engineer Test

The Draw an Engineer Test (DAET) was developed by Dr. Christine Cunningham at the Boston Museum of Science and Meredith Knight at Tufts University and was used by the Engineering is Elementary organization at the Boston Museum of Science to investigate students' concept of an engineer (Knight & Cunningham, 2004). Through her interactions with elementary students, Cunningham noticed that while we are surrounded by products created by engineers in our everyday lives, there are a lot of stereotypes and misconceptions of engineering and specifically what types of activities engineers do. Cunningham and Knight developed the DAET instrument to get a baseline understanding of what students thought an engineer was and what types of activities they do. These results were used to help aid in improving instruction, helping female minorities, and to connect technology with engineering.
Cunningham and Knight got the basic idea of the drawing an engineer instrument from the Draw A Scientist Test (DAST) which was developed by Mead and Metraux in 1957 and later refined by Chambers in 1983 (Chambers, 1983). In this assessment students were asked to draw a scientist. Among the various conclusions of this study, they found that most participants depicted scientists as male (Knight & Cunningham, 2004). The DAET also looked at tools, equipment and various visuals that were drawn by the students.

Using the DAET, students are instructed to draw an engineer at work (Knight & Cunningham, 2004). Researchers then use a rubric to look at each of the drawings and then group the drawings in categories according to gender of the drawn engineer, tools/equipment the engineer is using, and themes of the drawings such as whether the engineer drawn is building, driving, creating, fixing, designing, calculating, etc. (Knight & Cunningham, 2004). The preliminary study had 384 students who participated. They found that there were still a lot of misconceptions that students had about engineers such as thinking that engineers drive trains and spend much of their time fixing things. From its inception in 2004, the DAET has been used in many STEM-related research studies at the elementary and middle school level.

In a recent study by Walsh and Wright (2020), the DAET was given to multiple technology and engineering classes of all female students and found that about half of the students drew female engineers. Walsh had mixed classes of both male and females do the same and found that no one in the class including the females drew a female engineer. This seems to suggest that the grouping of all females might impact students’ perceptions of the gender of an engineer or technologist.
2.7 Research Question

What impact will participation by female students in an all-female technology and engineering course have on their concept of and interest in technology and engineering? To answer this research question, the following sub-questions were considered.

2.7.1 Interest in Learning About Technology and Engineering

Will female students’ interest in learning about technology and engineering, as measured by gain scores on a pre-test/post-test application of the Technology and Engineering Attitude Scale (TEAS), be large enough to be considered statistically or practically significant after participation in the treatment?

2.7.2 Interest in a Technology and Engineering Career

Will female students’ interest in a technology and engineering career, as measured by gain scores on a pre-test/post-test application of the Technology and Engineering Attitude Scale (TEAS), be large enough to be considered statistically or practically significant after participation in the treatment?

2.7.3 Perceived Abilities of Females to Participate in Technology and Engineering

Will female students’ perceptions of their abilities to participate in technology and engineering, as measured by gain scores on a pre-test/post-test application of the Technology and Engineering Attitude Scale (TEAS), be large enough to be considered statistically or practically significant after participation in the treatment?
2.7.4 **Students’ Concept: What Is an Engineer and What Types of Activities Do They Perform?**

Will a qualitative investigation of pre Draw an Engineer Test (DAET) and post DAET drawings submitted by students in the all-female middle school Exploring Technology Class indicate a clearer understanding of what engineers do (e.g., designing solutions as opposed to fixing and repairing) for female students? Further, will the qualitative analysis of female student drawings demonstrate increased perceptions that females can be engineers after participation in the treatment?
3 METHODOLOGY OF THE RESEARCH

3.1 Sample and Population in the Study

The population in this study was middle school students from a mostly middle-class suburban school district in Utah. To help female students feel more comfortable with the prospect of taking classes with technology and engineering content, the school district provided female students an opportunity to sign up for an all-female Exploring Technology Class offered to all 7th grade students. The general goal of the Exploring Technology class, as outlined by the Utah State Board of Education (USBE, 2019), is to “introduce middle school students to the world of technology and engineering through units of instruction and activities related to: manufacturing, information, communication, transportation, agriculture, biotechnology, construction, medical, energy and power technologies”. Students are also taught safety, the engineering design process, and historical and societal effects of technology (USBE, 2019).

The sample in this study consisted of 7th grade students enrolled in four sections of the Exploring Technology course at American Fork Junior High School. The potential treatment group in this study consisted of two all-female classes with a total of 53 students. Forty-One students completed the parent and student permission slips required to participate in the study and thus became the final treatment group. The control group was two mixed male and female classes with a potential of 79 students. Eleven female students and 36 male students for a total of 57 students completed the permission documents and thus became the control group. It should
also be noted that those students that did not chose to participate in the study were included in all classroom activities, but data was not collected for these students. Finally, the creation of the treatment and control groups was not manipulated by the investigator, but rather resulted from the regular class scheduling process instigated by the Alpine School District.

In the summary data below in table 3.1 the participants are not consistent pre and post TEAS. This is due to confounding factors of which the largest was the COVID-19 pandemic. During the pandemic students would be quarantined for large periods of time for safety. In some cases, students would miss up to six weeks. This made it difficult to get consistent numbers especially in the collection of blind data.

<table>
<thead>
<tr>
<th></th>
<th>Pre TEAS</th>
<th>Post TEAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>46</td>
<td>45</td>
</tr>
<tr>
<td>Female</td>
<td>51</td>
<td>52</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>97</strong></td>
<td><strong>97</strong></td>
</tr>
</tbody>
</table>

**Table 3-1: Male Female Participation in the TEAS**

**Figure 3-1: Total Male Female Participation in the TEAS**
Table 3-2: Total Male Female Participation by Class Period

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>A3</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>B1</td>
<td>N/A</td>
<td>20</td>
</tr>
<tr>
<td>B2</td>
<td>N/A</td>
<td>20</td>
</tr>
</tbody>
</table>

Figure 3-2: Pre Male Female Participation by Class Period

Table 3-3: Post Male Female Participation by Class Period

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>A3</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>B1</td>
<td>N/A</td>
<td>22</td>
</tr>
<tr>
<td>B2</td>
<td>N/A</td>
<td>19</td>
</tr>
</tbody>
</table>
Figure 3-3: Post Male Female Participation by Class Period

On the top left is a table with a breakdown of the males and females in that took the pre and post TEAS. Below that is a breakdown of males and females by class periods A2, A3, B1, and B2. On the right is a bar chart showing the corresponding data.

There were 97 students in the four classes who opted to participate in the TEAS, all in a 7th grade Exploring Technology class at American Fork Junior high school in American Fork Utah. In regards to the control group, at the beginning of the semester there were 57 students in the mixed male and female class with 11 of the students being female. At the end of the semester there were 56 students in the mixed class with 11 of these students being female. In regard to the treatment group, at the beginning of the semester there were 39 students in the all-female class and at the end of the semester there were 41 students in the all-female class. Table 3-1 shows the breakdown of the students by class and by gender.

3.2 Procedures/Data Collection/Instrumentation (TEAS)

At the start of the term, all classes were given the Technology and Engineering Attitude Scale (TEAS). The questions on the TEAS are found in Appendix A. The TEAS survey uses a
Likert scale, in which: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree. At the end of the term, students were given the same TEAS and any differences between mean gain scores of the two groups were used to determine impact/significance.

Note: Questions for the TEAS were based upon those found in the Technology Attitude Scale (TAS) (Jeffrey, 1993) and the Pupil’s Attitudes Toward Technology-United States of America (PATT-USA) survey instruments, used to investigate student attitudes toward technology. While no reliability coefficients were described by Cook (2009), Cronbach Alpha reliability coefficients of the TAS we found to be 0.81 (Attitudes Toward Technology) and 0.83 (Concept of Technology). The PATT reported similar reliability coefficients of the various subscales (Wolters, 1989).

Subscales of the TEAS are as follows:

1. Interest in Learning about Technology and Engineering,
2. Interest in a Technology or Engineering Career,
3. Importance and Contribution of Technology and Engineering to Society,
4. Perceived Difficulty of Technology and Engineering,
5. Relationship of Technology and Engineering to Math and Science,
6. Gender and Technology and Engineering
7. Connection of Technology and Engineering to Problem Solving
8. Student’s perceived Problem-Solving Capability in Technology and Engineering.

Note: For the purposes of answering the research questions in this study, the focus will be on the TEAS subscales #1, #2, and #6.
3.3 Analysis of TEAS Results: Treatment vs Control Group

With n-sizes of 57 students (control) and 39 students (treatment), descriptive statistics were used to obtain a baseline measure and see if there were any initial differences between the treatment and control groups after the administration of the TEAS pre-test. Inferential statistics in the form of t-test were then used to see if these differences were statistically significant on the pre and post-tests.

While estimates of statistical significance provide the researcher with indications whether the probability of a result is true, estimates of practical significance provide information regarding the magnitude of differences between mean scores and relationships that are independent of sample size and in a standardized form. Estimates of practical significance are typically calculated as effect sizes. In addition to the tests of statistical significance, the standardized mean difference (SMD) effect size, described by Glass (1977), which enables researchers to estimate the extent to which the distributions of scores for the pre-test and post-test overlap, was used as a measure of practical significance. The practical significance also is used to help understand the data with small effect sizes where the p-score cannot be calculated.

Because standards for determining when an effect size is practically significant are somewhat arbitrary, standards suggested by leading researchers in the social sciences were used. For example, Cohen (1988) has suggested that 0.20 is a small effect, 0.50 is a medium effect, and 0.80 is a large effect. The criterion for statistical significance of the independent t-test was the traditionally accepted p= .05.
3.4 Analysis of TEAS Results: Females in Control vs Treatment Group

To investigate potential differences between the females in the control group (n=11) and the classes of all-female students in the treatment group (n=39), descriptive statistics were again used. However, a t-test to see if any statistically significant differences existed was not employed because of the small number of females in the control group and the typical rule of thumb for using this test of inferential statistics is an n-size of 30 or greater. Instead, the Hedges’ G calculation, which provides a measure of effect size for dissimilar sample sizes was used to investigate differences between the groups in terms of practical significance (Stangroom, 2021).

3.5 Analysis of TEAS Results: Gain Scores

To answer Research Question #1 regarding the impact of the treatment (i.e., having female students sign up for an all-female class and allowing them to participate in a semester-long engagement of technology and engineering related activities and how that treatment might impact their attitudes toward engineering), gain scores, calculated by comparing the mean scores from the pre and post-tests of the individual items of the TEAS, were then analyzed using a t-test to see if the gain scores were statistically significant. In addition, standardized mean difference (SMD) effect sizes were used as a measure of practical significance.

3.6 Procedures: Draw an Engineer Test

Another assessment tool used in this study was the Draw an Engineer Test or DAET (Knight & Cunningham, 2004). In the DAET, students are given 20 minutes to write a brief sentence of what they think an engineer does and then express their thoughts about what an
engineer looks like and what types of activities engineers participate in through a drawing. The DAET was conducted at the beginning of the semester before the students had participated in any technology or engineering-related activities and then completed again at the end of the semester after they participated in technology and engineering activities.

3.7 Analysis: Draw an Engineer Test

To analyze the DAET a team of researchers in the school looked at the written descriptions and used a coding instrument developed previously for the DAET to indicate themes of what an engineer does, leaving flexibility for possible new themes to emerge. The DAET reviewers consisted of two male technology and engineering teachers, a female business teacher, and a female English teacher. The rubrics were explained to each of the reviewers along with information on how to tally their results. Each were instructed to use their best judgement while evaluating each picture.

Themes from previous research using the DAET include: An engineer - Builds, Fixes, Creates, Designs, Drives, Improves, Calculates, Invents, Studies and Don’t Know. Tallies were marked for each of the themes and then these tallies were translated into percentages by taking the total number of tallies and dividing it to allow the comparison of pre-post of the treatment group as well as a comparison of the treatment and control groups. The result of the tallies of each of the evaluators was compared for (inter-rater) reliability and accuracy which can be found in section 4.5.

To analyze the DAET drawings the same team of researchers used a coding instrument to first determine “what an engineer looks like” in terms of gender, and second, in terms of what
types of activities engineers participate in. When evaluating the drawings for indications of
gender, evaluators used a coding instrument modeled after that used by Knight and Cunningham
and others (Knight & Cunningham, 2004) that included items such as facial hair, length of hair,
clothing, and other contextual clues to help determine if the gender is male, female or if the
gender is undeterminable.

When coding for the “types of activities” an engineer participates in, the previous coding
themes of an engineer - Builds, Fixes, Creates, Designs, Drives, Improves, Calculates, Invents,
Studies and Don’t Know was be used. Artifacts from the drawing, including tools (hard hats,
safety glasses, computers, calculators) and products (bridges, buildings, roads, computers, cars)
will be used to identify the themes. Tallies are created for each of the themes and then these
tallies are translated into percentages to allow comparison of pre-post of the treatment group as
well as a comparison of the treatment and control groups. The result of the tallies of each of the
evaluators were compared for (inter-rater) reliability and accuracy and are in section 4-4.

Note: Approval from the Alpine School District (ASD) to conduct this study was granted
by the ASD’s research coordinator: David Mower (dmower@alpinedistrict.org), and by BYU’s
IRB office.
4 FINDINGS

4.1 Restating the Purpose

The purpose of this study was to investigate potential changes in female students’ concept of, and interest toward, technology and engineering. To accomplish this purpose, research questions were asked which allowed researchers to investigate female students’ attitudes toward technology and engineering as measured by the Technology and Engineering Attitude Scale (TEAS). In addition, the Draw and Engineer Test (DAET), was used to investigate female students’ concepts of what an engineer is and what types of activities they participate in. The findings of the various research questions are provided in the sections below.

4.2 Findings Relevant to Research Question

4.2.1 Interest in Learning About Technology and Engineering

Five questionnaire items from the TEAS (#1, #12, #14, #19, #20) dealt specifically with students’ general interest in learning about technology and engineering. Question #1 was a straightforward question about students’ general interest in learning about technology and engineering while Question #12 tried to determine student interest by asking them how well they perceived they might perform in an advanced technology and engineering class. Question #14 investigated interest by determining whether students feel there should be technology and
engineering classes in their school while Question #19 allowed students to respond whether they would like to learn more about technology and engineering. Finally, Question #20 tried to determine student interest by asking them if they were interested in joining a technology and engineering club at the school. The findings for both the pre-test and post-test, including mean scores, standard deviations, p-scores and effect sizes are presented in Tables 4.1 through 4.5.

4.2.1.1 Pre-Test: Control vs Treatment

Table 4-1: Pre-Test: Interest in Technology and Engineering

<table>
<thead>
<tr>
<th>Question</th>
<th>Control Group (N=57)</th>
<th>Treatment Group (N=39)</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Score ((\bar{x}))</td>
<td>Standard Deviation</td>
<td>Mean Score ((\bar{x}))</td>
<td>Standard Deviation</td>
<td>P-Score</td>
<td>ES*</td>
</tr>
<tr>
<td>#1</td>
<td>4.386</td>
<td>0.67</td>
<td>4.075</td>
<td>0.74</td>
<td>0.033**</td>
<td>0.46</td>
</tr>
<tr>
<td>#12</td>
<td>4.035</td>
<td>0.91</td>
<td>3.925</td>
<td>0.60</td>
<td>0.506</td>
<td>0.12</td>
</tr>
<tr>
<td>#14</td>
<td>4.579</td>
<td>0.86</td>
<td>4.575</td>
<td>0.60</td>
<td>0.980</td>
<td>0.00</td>
</tr>
<tr>
<td>#19</td>
<td>4.123</td>
<td>0.95</td>
<td>4.225</td>
<td>0.66</td>
<td>0.557</td>
<td>0.11</td>
</tr>
<tr>
<td>#20</td>
<td>3.561</td>
<td>1.05</td>
<td>3.400</td>
<td>1.02</td>
<td>0.451</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

** Designates statistical significance at the 0.05 level

*Glass’ Delta Effect Size

Given that a 5-point Likert Scale was used to collect pre-test data, with 1 = strongly disagree, 3 = neutral and 5 = strongly agree, the initial baseline mean scores for the mixed students in the control group ranged from 3.5 to 4.5 which indicated that students were neutral or
leaning toward agreed and strongly agreed that they were interested in learning about technology and engineering. Similarly, the baseline mean scores for the all-female students in the treatment ranged from 3.4 to 4.5, representative of a neutral to agreed and strongly agreed indication that they were interested in learning about technology and engineering. From Table 4.1, the interest scores from the control (mixed) group were higher than the interest scores of the treatment (all-female) group for all but Question #19.

Another data characteristic to note is the size of the standard deviations on each of the interest items for both the control and treatment groups with many of the standard deviations reaching levels of 0.9 or greater on a five-point scale. This would indicate a sizable amount variability in the student responses regarding their interest in learning about the topic of technology and engineering.

The only question in which a difference in scores on the pre-test between the mixed (control) group and the all-female (treatment) group was large enough to be statistically significant was Question #1: “I am interested in technology and engineering”, indicating that at the beginning of the semester, students in the control group had a statistically significant greater degree of interest (p = .033) in learning about technology and engineering than students in the treatment group. Question #1 also had a calculated effect size of ES=0.46 which indicated a moderate practical significant difference between the two groups on this question. The effect sizes for the remaining questions ranged from 0-0.15 which would be considered a small difference between the two groups on interest in learning about technology and engineering. This provides a baseline from which to compare the post-test scores at the end of the semester.
4.2.1.2 Pre-Test: Females in Control vs Treatment

Of specific interest to this research study is the comparison of the female students’ scores in the mixed (control) group and the all-female (treatment) group. The data in Table 4-2 indicate that generally, the mean pre-test scores for the (all-female) treatment group reflected more interest in technology and engineering at the beginning of the semester than the scores for the female students in the control group. Given the small n-size of the females in the control group, an effect size was used to indicate the practical significant differences between the two groups rather than a test of statistical significance.

<table>
<thead>
<tr>
<th>Question</th>
<th>Females Control (N=11)</th>
<th>Treatment Group (N=39)</th>
<th><strong>ES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>3.91</td>
<td>4.075</td>
<td>0.225</td>
</tr>
<tr>
<td>#12</td>
<td>3.27</td>
<td>3.925</td>
<td>0.803</td>
</tr>
<tr>
<td>#14</td>
<td>4.18</td>
<td>4.575</td>
<td>0.505</td>
</tr>
<tr>
<td>#19</td>
<td>3.36</td>
<td>4.225</td>
<td>1.100</td>
</tr>
<tr>
<td>#20</td>
<td>2.91</td>
<td>3.400</td>
<td>0.470</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

** Hedges’ g Effect Size

For two of the test items (#12, #19) the calculated effect sizes of 0.803 and 1.10 would be considered a large effect size by education researchers (Cohen, 1988). Question #12 asks students if they “think they would do well in advanced technology and engineering courses” and
question #19 wants to know if students “want to learn more about technology and engineering at school”. Effect sizes this large clearly indicate that the students in the all-female treatment group had higher interest in learning about technology and engineering than the female students in the mixed classes. While the effect sizes for the remaining items (#1, #14, #20) would be considered small to moderate, they reinforce the premise that the students in the all-female treatment group indicated a stronger interest in learning about technology and engineering that the female students in the mixed classes.

4.2.1.3 Post-Test: Control vs Treatment

When considering the post-test data, it should be noted that after participating in technology and engineering activities over the course of a semester, that all student scores for both the control and treatment groups on interest in learning about technology and engineering diminished (Compare Table 4.1 to Table 4.3). For example, on Question #1, students in the control group went from a M = 4.386 to a M = 4.071 while students in the treatment group went from a M = 4.075 to a M = 3.854. Likewise, for Question #12 the scores for the control group went from 4.035 to 3.71 and 3.925 to 3.512 for the treatment group. From Table 4.3 It can be seen that this pattern continues for Question #14 (Control: 4.579 to 4.25, Treatment: 4.575 to 4.22), Question 19 (Control: 4.123 to 3.875, Treatment: 4.225 to 3.732), and Question #20 (Control: 3.561 to 3.411, Treatment: 3.4 to 3.0). In summary, student interest in learning about technology and engineering, as measured from the pre to post test, diminished for both the control and treatment groups.

Finally, when comparing the mean scores of the control group to the mean scores of the treatment group on each of the five-interest questions, none of the differences in mean scores
were for any of the items were large enough to be statistically significant. The calculated effect sizes (0.03 to 0.38) also indicate small practical significant differences between the two groups on the post test.

Table 4-3: Post-Test: Interest in Technology and Engineering

<table>
<thead>
<tr>
<th>Control Group (N=57)</th>
<th>Treatment Group (N=41)</th>
<th>P-Score Control vs Treatment</th>
<th>ES*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question #1</td>
<td>4.071</td>
<td>0.93</td>
<td>3.854</td>
</tr>
<tr>
<td>#12</td>
<td>3.714</td>
<td>1.06</td>
<td>3.512</td>
</tr>
<tr>
<td>#14</td>
<td>4.25</td>
<td>0.98</td>
<td>4.220</td>
</tr>
<tr>
<td>#19</td>
<td>3.875</td>
<td>1.05</td>
<td>3.732</td>
</tr>
<tr>
<td>#20</td>
<td>3.411</td>
<td>1.09</td>
<td>3.000</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

** Designates statistical significance at the 0.05 level

*Glass’s Delta Effect Size

4.2.1.4 Post-Test: Females in Control vs Treatment

Given the small n-size of the females in the control group (n=11), an effect size was used to indicate the practical significant differences between the two groups on the mean post-test scores for each of the interest items rather than a test of statistical significance. From Table 4-4 It can be seen that the effect sizes ranged from 0.01 on Question #19 to 0.57 on Question #1 indicating no difference to a moderate practical significant difference between the two groups on
the post-test. Note that at the beginning of the semester on the pre-test, these same effect sizes (Table 4-2) ranged from 1.1 to 0.225 and indicated a moderate to large difference between the two groups. Between the pre-test and post-test, the differences between the females in the control group and the all-female treatment groups on interest in learning about technology and engineering diminished.

Table 4-4: Post-Test: Interest in Technology and Engineering

<table>
<thead>
<tr>
<th>Females in Control vs Treatment</th>
<th>Females Control (N=11)</th>
<th>Treatment Group (N=41)</th>
<th>*Effect Size: Females Control vs Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Mean Score (x̅)</td>
<td>Standard Deviation</td>
<td>Mean Score (x̅)</td>
</tr>
<tr>
<td>#1</td>
<td>3.45</td>
<td>1.08</td>
<td>3.85</td>
</tr>
<tr>
<td>#12</td>
<td>3.18</td>
<td>1.03</td>
<td>3.51</td>
</tr>
<tr>
<td>#14</td>
<td>3.91</td>
<td>1.16</td>
<td>4.22</td>
</tr>
<tr>
<td>#19</td>
<td>3.73</td>
<td>1.21</td>
<td>3.73</td>
</tr>
<tr>
<td>#20</td>
<td>3.09</td>
<td>1.00</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

* Hedges’ g Effect Size

4.2.1.5 Gain Scores: Pre-Test vs Post-Test

Because of the noted decrease in scores from the pre-test to the post-test for both the control and treatment groups on each of the items measuring interest in learning about technology and engineering, gain scores were calculated to investigate if this decrease in interest
was of a significant value. Investigating these gain scores allows the researcher to help answer the first research question investigating the impact the treatment had on female students’ interest in learning about technology and engineering. Given that research question #1 specifically dealt with female students’ interest in technology and engineering, gain scores of only the females in the control group along with the all-female treatment groups are presented in Table 4-5.

Table 4-5: Gain Scores: Females in the Control vs Treatment

<table>
<thead>
<tr>
<th>Q #</th>
<th>Gain Female Treatment</th>
<th>Gain Female Control</th>
<th>Gain</th>
<th>*ES</th>
<th>Gain</th>
<th>*ES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-test N=39 Post-test N=41</td>
<td>Pre-test N=11, Post-test N=11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Pre x̅  4.075  0.74  3.854  0.57  -0.22  0.132  -0.3   3.909  0.70  3.455  1.08  -0.45  -0.66</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post x̅  3.854  0.57  3.400  0.92  -0.40  0.066  -0.39  2.909  1.14  3.091  1.0  0.18  0.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Pre x̅  3.925  0.60  3.512  0.78  -0.41  0.010**  -0.69  3.273  1.35  3.182  1.03  -0.09  -0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post x̅  3.512  0.78  3.000  0.92  -0.40  0.066  -0.39  2.909  1.14  3.091  1.0  0.18  0.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Pre x̅  4.575  0.60  4.220  0.79  -0.36  0.025**  -0.59  4.182  1.25  3.909  1.16  -0.27  -0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post x̅  4.220  0.79  3.732  0.74  -0.49  0.002**  -0.75  3.364  1.12  3.727  1.21  0.36  0.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Pre x̅  4.225  0.66  3.732  0.74  -0.49  0.002**  -0.75  3.364  1.12  3.727  1.21  0.36  0.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post x̅  3.732  0.74  3.000  0.92  -0.40  0.066  -0.39  2.909  1.14  3.091  1.0  0.18  0.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

** Designates statistical significance at the 0.05 level

*Effect Size

When considering the gain scores in Table 4.5, one of the first things to note is the negative gain scores for each of the interest items for the all-female treatment group. This was not the case for the females in the control group. In fact, for two of the interest questions (#19
and #20) the females in the control group actually had positive gain scores from the pre-test to the post-test.

When considering the gain scores for the all-female treatment group. Three of the items (#12, #14 & #19) had negative gain scores large enough to be considered statistically significant at the 0.05 level. In question #12, the students were asked if they would be interested in taking a higher-level technology and engineering course. The finding from this question is important in answering Research Question #1 in that the students in the all-female class responded that they had significantly less interest in taking a higher-level technology and engineering course.

The second significant question was question #14 which asks if they think there should be an engineering and technology class at their school. Lastly, question #19 asked students if they wanted to learn more about engineering and technology at school. From the data that was collected, it appears that students in the all-female (treatment) class were significantly less interested in learning more about technology and engineering at school at the end of the semester when compared to the beginning of the class.

In looking more closely at the scores, the female students in the mixed class indicated in three of the questions (#1, #12, #14) that they had less interest in technology and engineering, while in the other two questions (#19, #20) they indicated greater interest in technology and engineering. Effect sizes of 0.32 for Question #19 and 0.16 for Question #20 would indicate that this greater interest between pre to pos-test to be of a small to moderate value.

4.2.2 Student Interest in a Technology and Engineering Career

Five questionnaire items from the TEAS (#10, #13, #17, #23, #28) dealt specifically with students' general interest in a technology or engineering career. Question #10 investigated
whether students would like a job that involved technology and engineering, while Question #13 asked students if they felt a technology or engineering job would be fun. Questions #17 and #23 asked students if they would like to be a technologist or engineer when they grow up and finally Question #28 asked student if they thought a job in technology and engineering would be boring or dull. Note that Question #28 is asked from a negative perspective, so a higher score represents less interest in a technology or engineering career. The findings for both the pre-test and post-test, including mean scores, standard deviations, p-scores and effect sizes are presented in Tables 4-6 Through 4-10.

### 4.2.2.1 Pre-Test: Control vs Treatment

Given that a 5-point Likert Scale was used to collect pre-test data, with 1 = strongly disagree, 3=neutral and 5 = strongly agree, the initial baseline scores for the both the treatment and control groups (Table 4-6) would indicate that students are generally neutral to agree that they are interested in a technology and engineering career.

**Table 4-6: Pre-Test: Interest in a Technology and Engineering Career**

<table>
<thead>
<tr>
<th>Question</th>
<th>Control Group (N=57)</th>
<th>Treatment Group (N=39)</th>
<th>P-Score</th>
<th>ES ***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Score (x̅)</td>
<td>Standard Deviation</td>
<td>Mean Score (x̅)</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>#10</td>
<td>3.614</td>
<td>1.00</td>
<td>3.225</td>
<td>0.80</td>
</tr>
<tr>
<td>#13</td>
<td>4.070</td>
<td>0.96</td>
<td>3.900</td>
<td>0.85</td>
</tr>
<tr>
<td>#17</td>
<td>3.035</td>
<td>0.98</td>
<td>2.850</td>
<td>0.78</td>
</tr>
</tbody>
</table>
The interest scores from the control (mixed) group were higher than the interest scores of the treatment (all-female) group on each of the questions. However, the only question in which a difference in mean scores on the pre-test between the mixed (control) group and the all-female (treatment) group was large enough to be statistically significant was Question #10: “I would like a job that lets me do a lot of engineering and technology”, indicating that at the beginning of the semester, students in the control group had a statistically significant greater degree of interest ($p = .043$) in technology and engineering career than students in the treatment group.

Another data characteristic to note is the size of the standard deviations on each of the interest items for the control group with many of the standard deviations reaching levels of 0.9 or greater on a five-point scale. This would indicate a sizable amount variability in the student responses regarding their interest in a technology and engineering career. The variability in the scores in the treatment group were less than the control group but still ranged from 0.76 to 0.85.
### 4.2.2.2 Pre-Test: Females in Control vs Treatment

#### Table 4-7: Pre-Test: Interest in a Technology and Engineering Career

<table>
<thead>
<tr>
<th>Question</th>
<th>Females Control (N=11)</th>
<th>Treatment Group (N=39)</th>
<th><strong>ES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Score ((\bar{x}))</td>
<td>Standard Deviation</td>
<td>Mean Score ((\bar{x}))</td>
</tr>
<tr>
<td>#10</td>
<td>3.000</td>
<td>0.77</td>
<td>3.225</td>
</tr>
<tr>
<td>#13</td>
<td>3.545</td>
<td>1.21</td>
<td>3.900</td>
</tr>
<tr>
<td>#17</td>
<td>2.727</td>
<td>1.01</td>
<td>2.850</td>
</tr>
<tr>
<td>#23</td>
<td>2.545</td>
<td>0.82</td>
<td>2.900</td>
</tr>
<tr>
<td>#28*</td>
<td>2.364</td>
<td>1.12</td>
<td>1.725</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

* Designates a lower score equals a more positive perception

** Hedges’ g Effect Size for Females in Control vs Treatment

The data in Table 4-7 indicate that generally, the mean pre-test scores for the (all-female) treatment group reflected more interest in an engineering and technology career at the beginning of the semester than the mean scores for the female students in the control group. Given the small n-size of the females in the control group, an effect size was used to indicate the practical significant differences between the two groups rather than a test of statistical significance.

Only one test item, Question #28 in which students were asked if they thought that, “Working in engineering and technology for a job would be dull”, indicated differences between the two groups that reflected an effect size that would be considered practically significant. The
effect sizes (0.15 to 0.42) on the rest of the questions (#10, #13, #17 and #23) would be considered small to moderate but reinforce the premise that the students in the all-female treatment group indicated a stronger interest in an engineering and technology career than the female students in the mixed classes.

4.2.2.3 Post-Test: Control vs Treatment

Table 4-8: Post-Test: Interest in a Technology and Engineering Career

<table>
<thead>
<tr>
<th>Question</th>
<th>Control Group (N=57)</th>
<th>Treatment Group (N=41)</th>
<th>P-Score</th>
<th>ES ***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Score (x̅)</td>
<td>Standard Deviation</td>
<td>Mean Score (x̅)</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>#10</td>
<td>3.464</td>
<td>1.11</td>
<td>3.171</td>
<td>0.77</td>
</tr>
<tr>
<td>#13</td>
<td>3.893</td>
<td>0.97</td>
<td>3.683</td>
<td>0.88</td>
</tr>
<tr>
<td>#17</td>
<td>3.125</td>
<td>1.06</td>
<td>2.683</td>
<td>0.82</td>
</tr>
<tr>
<td>#23</td>
<td>3.071</td>
<td>1.13</td>
<td>2.976</td>
<td>0.91</td>
</tr>
<tr>
<td>#28*</td>
<td>1.982</td>
<td>1.04</td>
<td>1.805</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

* Designates a lower score equals a more positive perception

** Designates statistical significance at the 0.05 level

*** Glass Delta Effect Size

When comparing the post-test scores (Table 4-8) of the control and treatment groups regarding their interest in an engineering and technology career, the only difference between the two groups that was large enough to be considered statistically significant was Question #17, “I
would like to be a technologist when I grow up” (p=0.029, ES=0.42). This would indicate that the students in the control, mixed male/female group were significantly more interested in being technologists than the all-female students in the treatment group. While the differences between the two groups on the remaining questions were not large enough to be considered statistically significant, the interest scores from the control group as indicated by the mean scores (3.46, 3.89, 3.12, 3.07, 1.98*) were generally higher scores than that of the treatment group (3.17, 3.68, 2.68, 2.97, 1.8*).

### 4.2.2.4 Post-Test: Females in Control vs Treatment

**Table 4-9: Post-Test: Interest in a Technology and Engineering Career**

<table>
<thead>
<tr>
<th>Females in Control vs Treatment</th>
<th>Females Control (N=11)</th>
<th>Treatment Group (N=41)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question</strong></td>
<td><strong>Mean Score ((\bar{x}))</strong></td>
<td><strong>Standard Deviation</strong></td>
</tr>
<tr>
<td>#10</td>
<td>2.818</td>
<td>0.94</td>
</tr>
<tr>
<td>#13</td>
<td>3.545</td>
<td>1.08</td>
</tr>
<tr>
<td>#17</td>
<td>2.636</td>
<td>0.64</td>
</tr>
<tr>
<td>#23</td>
<td>2.364</td>
<td>0.88</td>
</tr>
<tr>
<td>#28*</td>
<td>1.909</td>
<td>0.67</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

* Designates a lower score equals a more positive perception

** Hedges’ g Effect Size for Females in Control vs Treatment
Given the small n-size of the females in the control group (n=11), an effect size was used to indicate the practical significant differences between the two groups on the mean post-test scores for each of the interest items rather than a test of statistical significance. From Table 4-9 it can be seen that the effect sizes ranged from 0.06 on Question #17, “I would like to be a technologist when I grow up” to 0.68 on Question #23, “I would like to be an engineer when I grow up” indicating small to moderate practical significant differences between the two groups on the post-test. At the end of the semester of participating in technology and engineering activities, it would appear that the students in the treatment group have more interest in being engineers than the female students in the control group.

4.2.2.5 Gain Scores: Pre-Test vs Post-Test

Table 4-10 provides data related to female students’ interest in a career in engineering and technology as measured by gain scores from the pre-test to the post-test. Investigating gain scores allows the researcher to help answer the first research question investigating the impact the treatment had on female students’ interest in technology and engineering.

Regarding the all-female treatment group, none of the differences between the pre-test and post-test on any of the five question items were large enough to be considered statistically significant. Additionally, the calculated effect sizes were also small (-0.07 to -0.25) indicating that there was little change in interest toward a career in engineering and technology from the beginning to the end of the semester by the students in the treatment group. Meaning that their opinions were basically unchanged.
Table 4-10: Gain Scores: Interest in a Career in Engineering and Technology

Females in the Control vs Treatment

<table>
<thead>
<tr>
<th>Q #</th>
<th>Pre x</th>
<th>Pre SD</th>
<th>Post x</th>
<th>Post SD</th>
<th>Gain</th>
<th>P-Score</th>
<th><strong>ES</strong></th>
<th>Pre x</th>
<th>Pre SD</th>
<th>Post x</th>
<th>Post SD</th>
<th>Gain</th>
<th>*ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3.225</td>
<td>0.80</td>
<td>3.171</td>
<td>0.77</td>
<td>-.054</td>
<td>0.757</td>
<td>-.07</td>
<td>3.000</td>
<td>0.77</td>
<td>2.818</td>
<td>0.94</td>
<td>-0.182</td>
<td>-.24</td>
</tr>
<tr>
<td>13</td>
<td>3.900</td>
<td>0.85</td>
<td>3.683</td>
<td>0.88</td>
<td>-.217</td>
<td>0.260</td>
<td>-.25</td>
<td>3.545</td>
<td>1.21</td>
<td>3.545</td>
<td>1.08</td>
<td>-0.000</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>2.850</td>
<td>0.78</td>
<td>2.683</td>
<td>0.82</td>
<td>-.167</td>
<td>0.347</td>
<td>-.21</td>
<td>2.727</td>
<td>1.01</td>
<td>2.636</td>
<td>0.64</td>
<td>-0.091</td>
<td>-.09</td>
</tr>
<tr>
<td>23</td>
<td>2.900</td>
<td>0.85</td>
<td>2.976</td>
<td>0.91</td>
<td>.076</td>
<td>0.699</td>
<td>-.09</td>
<td>2.545</td>
<td>0.82</td>
<td>2.364</td>
<td>0.88</td>
<td>-0.182</td>
<td>-.22</td>
</tr>
<tr>
<td>28*</td>
<td>1.725</td>
<td>0.76</td>
<td>1.805</td>
<td>0.78</td>
<td>.080</td>
<td>0.640</td>
<td>-.11</td>
<td>2.364</td>
<td>1.12</td>
<td>1.909</td>
<td>0.67</td>
<td>-0.455</td>
<td>-.41</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

* Designates a lower score equals a more positive perception

** Designates statistical significance at the 0.05 level

***Glass Delta Effect Size:

The effect sizes calculated from the gain scores from the pre-test to the post-test for the female students in the mixed class were also generally small indicating little change in interest from the beginning to the end of the semester. The one exception to this is Question #28, which asked students if they thought a career in engineering and technology would be dull and boring. In this case a negative gain score (ES=-0.41) indicates that the female students in the control group did not agree with this statement more at the end of the semester than at the beginning of the semester.
4.2.3 Gender and Technology and Engineering

Another way to determine the impact that the treatment had on female students’ interest in and attitudes toward technology and engineering is to ask questions relative to gender and the perceived abilities that female students have in participating in technology and engineering. Questions #2, #8, #21, and #32 all deal with gender. Note that questions #2 and #32 were both worded in a negative way so that a lower score would indicate a more positive response to the question. Question #2 asked students if they felt that boys are better than girls at being engineers. Questions #8 and #21 asked students if they thought that girls can have technical jobs and if they think that girls would be successful in engineering and technology. Finally, Question #32 gauged student response relative to whether they thought that boys know more about engineering and technology than girls. The findings for both the pre-test and post-test, including mean scores, standard deviations, p-scores and effect sizes are presented in Tables 4-11 through 4-16.

4.2.3.1 Pre-Test: Control vs Treatment

From the data in Table 4-11, note that the P-Scores were all statistically significant when comparing the mean scores of the control and treatment groups in the pre-test data. This indicates that the all-female students in the treatment group had statistically significant higher perceptions of females’ ability to participate in technology and engineering than the students in the mixed, male and female, control group. The calculated effect sizes for each question support the findings of statistical significance ranging from 0.446 to 0.636 and are considered medium effect sizes (Sawilowsky, 2009).
4.2.3.2 Pre-Test: Females in Control vs Treatment

Of specific interest to this research study is the comparison of the female students’ scores in the mixed (control) group and the all-female (treatment) group. The data in Table 4-12 indicate that generally, the mean pre-test scores for the (all-female) treatment group reflected a more positive view on gender equality and technology and engineering at the beginning of the semester than the scores for the female students in the control group. Given the small n-size of the females in the control group, an effect size was used to indicate the practical significant differences between the two groups rather than a test of statistical significance. Question #2 had a small effect size while questions #8, #21 and #32 had moderate effect sizes that ranged from
0.429 to 0.0637. This tells us that in the pre-test data, females in the control were less positive about gender equality than that of the females in the treatment group.

Table 4-12: Pre-Test: Gender and Technology and Engineering

<table>
<thead>
<tr>
<th>Question</th>
<th>Females Control (N=11)</th>
<th>Treatment Group (N=39)</th>
<th><strong>ES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Score ($\bar{x}$)</td>
<td>Standard Deviation</td>
<td>Mean Score ($\bar{x}$)</td>
</tr>
<tr>
<td>#2*</td>
<td>1.82</td>
<td>0.75</td>
<td>1.65</td>
</tr>
<tr>
<td>#8</td>
<td>4.64</td>
<td>0.67</td>
<td>4.85</td>
</tr>
<tr>
<td>#21</td>
<td>4.64</td>
<td>0.67</td>
<td>4.88</td>
</tr>
<tr>
<td>#32*</td>
<td>1.64</td>
<td>1.03</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

* Designates a lower score equals a more positive perception

** Hedges’ g Effect Size for Females in Control vs Treatment

4.2.3.3 Post-Test: Control vs Treatment

When considering the post-test data, it should be noted that after participating in technology and engineering activities over the course of a semester, that all student scores for both the control and treatment groups on gender in technology and engineering were relatively the same (see Table 4-15 and 4-16). On question #2 students in the treatment group went from a M = 1.65 to a M = 1.41 while students in the control group went from a M = 1.650 to a M = 1.875. For questions #8, #21, and #32 There was little difference between the pre and post
scores. For the P-Scores there was little change but all were still significant. In summary, there was little change between the pre-test and post test scores with the treatment group indicating more positive perceptions of female abilities to participate in engineering and technology.

<table>
<thead>
<tr>
<th>Control vs Treatment</th>
<th>Control Group (N=57)</th>
<th>Treatment Group (N=41)</th>
<th>P-Score</th>
<th>ES ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question #2*</td>
<td>1.88</td>
<td>1.41</td>
<td>0.042**</td>
<td>0.359</td>
</tr>
<tr>
<td>Question #8</td>
<td>4.38</td>
<td>4.85</td>
<td>0.013**</td>
<td>0.409</td>
</tr>
<tr>
<td>Question #21</td>
<td>4.41</td>
<td>4.85</td>
<td>0.013**</td>
<td>0.411</td>
</tr>
<tr>
<td>Question #32*</td>
<td>1.80</td>
<td>1.24</td>
<td>0.005**</td>
<td>0.479</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

* Designates a lower score equals a more positive perception

** Designates statistical significance at the 0.05 level

*** Glass Delta Effect Size

### 4.2.3.4 Post-Test: Females in Control vs Treatment

Because of the small n-size of the females in the control group (n=11), an effect size was used to indicate the practical significant differences between the two groups on the mean post-test scores for each of the interest items rather than a test of statistical significance. From Table 4-14, it can be seen that the effect sizes ranged from being small 0.283 on Question #2, were it states, “Boys are better at being engineers than girls” to 1.186 on Question #8, “Girls can be as
successful doing engineering and technology as boys” indicating small to moderate practical significant differences between the two groups on the post-test. At the end of the semester of participating in technology and engineering activities, it would appear that the students in the treatment group had more positive perceptions of females’ ability to participate in technology and engineering than the female students in the control group.

Table 4-14: Post-Test: Gender and Technology and Engineering

<table>
<thead>
<tr>
<th>Females in Control vs Treatment</th>
<th>Females Control (N=11)</th>
<th>Treatment Group (N=41)</th>
<th><strong>ES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question</strong></td>
<td><strong>Mean Score (x̅)</strong></td>
<td><strong>Standard Deviation</strong></td>
<td><strong>Mean Score (x̅)</strong></td>
</tr>
<tr>
<td>#2*</td>
<td>1.64</td>
<td>1.23</td>
<td>1.41</td>
</tr>
<tr>
<td>#8</td>
<td>3.91</td>
<td>1.56</td>
<td>4.85</td>
</tr>
<tr>
<td>#21</td>
<td>4.00</td>
<td>1.54</td>
<td>4.85</td>
</tr>
<tr>
<td>#32*</td>
<td>1.73</td>
<td>1.21</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

* Designates a lower score equals a more positive perception

** Hedges’ g Effect Size for Females in Control vs Treatment

### 4.2.3.5 Gain Scores: Pre-Test vs Post-Test

Table 4-15 provides data related to female students’ ideas of gender in engineering and technology as measured by gain scores from the pre-test to the post-test. Investigating gain scores allows the researcher to help answer the first research question investigating the impact the treatment had on female students’ ideas of gender in technology and engineering.
Table 4-15: Gain Scores: Interest in a Career in Engineering and Technology

<table>
<thead>
<tr>
<th>Q #</th>
<th>Pre-Test N=39 Post-Test N=41</th>
<th>Gain Female Treatment</th>
<th>Pre-Test N=11, Post-Test N=11</th>
<th>Gain Female Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre x̅</td>
<td>Pre SD</td>
<td>Post x̅</td>
<td>Post SD</td>
</tr>
<tr>
<td>#2</td>
<td>1.65</td>
<td>1.13</td>
<td>1.41</td>
<td>0.67</td>
</tr>
<tr>
<td>#8</td>
<td>4.85</td>
<td>0.43</td>
<td>4.85</td>
<td>0.42</td>
</tr>
<tr>
<td>#21</td>
<td>4.88</td>
<td>0.34</td>
<td>4.85</td>
<td>0.36</td>
</tr>
<tr>
<td>#32</td>
<td>1.25</td>
<td>0.44</td>
<td>1.24</td>
<td>0.49</td>
</tr>
</tbody>
</table>

Note: Control Group=Mixed Male and Female Classes, Treatment=All-Female Classes

* Designates a lower score equals a more positive perception

** Designates statistical significance at the 0.05 level

***Glass Delta Effect Size:

From this table we see that the treatment group had a positive outlook on gender in technology and engineering in the beginning. We can also see that after the semester they stayed about the same in their responses with small gain scores and nothing being statistically significant. The effect sizes were also relatively small or even 0 in one case.

The gain scores for the females in the control group decreased on questions #8 and #21 with the effect sizes being large on #8 with 1.090 and #21 with a 0.955. Question #8 said, “Girls can be as successful doing engineering and technology as boys” and question #21, “A girl can
have a technical job.” From this we can see that the girls perceived that they will not be as successful as the boys after being grouped with them or that technical jobs are not be for girls.

In summary of the gender section of the TEAS, it appears that the mean treatment scores for the all-female (treatment) class were very high for the questions #8 and #21. This indicates that they strongly agreed with those statements of that girls can be as successful as boys and have technical jobs in technology and engineering. Looking at the mean scores the treatment produced more positive numbers than the controls group in the entire section. Because of this, the differences between the mean scores between the two groups was large enough to be considered statistically significant on all four questions. The effect sizes also indicate a moderate to high level of practical significance. It is interesting to note the drop in scores and the large effect size that the control group had in table 4-15. It would appear that being with male peers, the female students in the control group’s perceptions on gender in technology and engineering changed.

### 4.2.4 Draw an Engineer Test (DAET)

The DAET was given to students at the beginning of the course and at the end. The students in the control and treatment groups were simply instructed each time to draw an engineer. The results were tallied and put into categories by four different researchers. There were two different categorizations, that of theme or type and gender (Knight & Cunningham, 2004). The rubrics the researchers used can be found in Appendix B. The results were tallied and compared for interdependent reliability. The Intraclass Correlation Coefficient resulted in a 96.6%. This is an excellent reliability coefficient according to Koo and Li (2016). Table 4-17 is pre data with the averaged numbers and percentages next to them. Table 4-18 is the post data with the averages and percentages next to them.
Table 4-16: DAET Tallies and Percentages - Average of the 4 Raters

<table>
<thead>
<tr>
<th>Theme</th>
<th>Pre: Male Control</th>
<th>Post: Male Control</th>
<th>Pre: Female Control</th>
<th>Post: Female Control</th>
<th>Pre: Female Treatment</th>
<th>Post: Female Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build/fix</td>
<td>25.5</td>
<td>10.5</td>
<td>4.5</td>
<td>0.5</td>
<td>18.75</td>
<td>7.75</td>
</tr>
<tr>
<td></td>
<td>69%</td>
<td>60%</td>
<td>62%</td>
<td>17%</td>
<td>61%</td>
<td>31%</td>
</tr>
<tr>
<td>Design</td>
<td>6</td>
<td>5</td>
<td>0.5</td>
<td>0.5</td>
<td>7.5</td>
<td>12.25</td>
</tr>
<tr>
<td></td>
<td>16%</td>
<td>29%</td>
<td>7%</td>
<td>17%</td>
<td>25%</td>
<td>49%</td>
</tr>
<tr>
<td>Mechanical</td>
<td>4.75</td>
<td>2</td>
<td>1.25</td>
<td>1</td>
<td>3</td>
<td>4.25</td>
</tr>
<tr>
<td></td>
<td>13%</td>
<td>11%</td>
<td>17%</td>
<td>33%</td>
<td>10%</td>
<td>17%</td>
</tr>
<tr>
<td>Civil</td>
<td>0.75</td>
<td>0</td>
<td>0.5</td>
<td>0.25</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>2%</td>
<td>0%</td>
<td>7%</td>
<td>8%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Train</td>
<td>0</td>
<td>0%</td>
<td>0.5</td>
<td>0.75</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
<td>7%</td>
<td>25%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Lab</td>
<td>0</td>
<td>0%</td>
<td>0</td>
<td>0%</td>
<td>0.75</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>27.25</td>
<td>10</td>
<td>6.25</td>
<td>4</td>
<td>21.25</td>
<td>6.25</td>
</tr>
<tr>
<td></td>
<td>74%</td>
<td>57%</td>
<td>76%</td>
<td>80%</td>
<td>58%</td>
<td>18%</td>
</tr>
<tr>
<td>Female</td>
<td>0.5</td>
<td>0%</td>
<td>0.75</td>
<td>0%</td>
<td>0%</td>
<td>9.25</td>
</tr>
<tr>
<td></td>
<td>1%</td>
<td>0%</td>
<td>9%</td>
<td>0%</td>
<td>25%</td>
<td>62%</td>
</tr>
<tr>
<td>Undetermined</td>
<td>9.25</td>
<td>7.5</td>
<td>1.25</td>
<td>1</td>
<td>6.25</td>
<td>6.75</td>
</tr>
</tbody>
</table>

Note: Percent was found by taking the number of participants in each column group and dividing it by the number in the row.

4.2.4.1 Theme

In regard to theme, or what types of activities the students perceived that engineers participate in, at the beginning of the semester, the male students in the control group strongly perceived engineers to be persons that build and fix things as was represented in 69% of the drawings. Note that at the end of the semester this percentage dropped to 60% for build and fix while design-type drawings increased from 16% at the beginning of the semester to 29% at the end of the semester. It would appear that over the course of a semester the male students in the
control classes were able to increase their perception that engineers design things even though “build and fix things” is still predominant in their perceptions.

At the beginning of the semester, female students in the control group also strongly perceived engineers to be persons that build and fix things as represented by 62% of their drawings. Mechanical-type drawings were also prevalent in their drawings (17%) and then design, civil and trains each were represented in 7% of the drawings. By the end of the semester, drawings that represented building and fixing dropped dramatically to 17% while engineers as persons that worked with mechanical things jumped dramatically to 33% of the drawings. Design type drawings increased from 7% to 17% and interestingly, engineers as someone that drives a train went from 7% at the beginning of the semester to 25% at the end of the semester.

One of the most dramatic changes in perceiving what an engineer does, was indicated by the females in the treatment group. While their concept of an engineer at the beginning of the semester was strongly build and fix (61%), this percentage dropped dramatically at the end of the semester (31%). Conversely their concept that an engineer is someone that designs increased from 25% of their drawings at the beginning of the semester to 49% of the drawings at the end of the semester. Note that an engineer is someone that works with mechanical things was also represented at both the beginning of the semester (10%) and the end of the semester (17%).

4.2.4.2 Gender

At the beginning of the semester, both males (74%) and females (76%) in the control group represented engineers as males in their drawings. By the end of the semester the male students only represented engineers as males in 57% of their drawings with many more of the
drawings being of undeterminable gender. The females in the control group increased slightly from 76% to 80% of their drawings having engineers being represented as males.

The female students in the treatment group represented males in their drawings as engineers in 58% of their drawings at the beginning of the semester with females being represented 25% of the time and undetermined being 17% of the drawings. At the end of the semester these numbers changed dramatically as only 18% of the drawings represented males with 62% of the drawings representing females and 20% undetermined. This data clearly indicates that the females in the treatment group had a change in perception as to whether an engineer can be represented as female.
5 CONCLUSIONS

5.1 Background and Overall Purpose for the Research

The purpose of this study was to investigate potential changes in female students’ concept of, and interest toward, technology and engineering when allowed to participate in an all-female technology and engineering class. Research questions were presented to investigate female students’ attitudes toward technology and engineering and their concept of what an engineer is, especially in terms of gender, and what types of activities an engineer typically participates in.

The inspiration for this research study began in 2017 when enrollment in the 9th grade Engineering Technology class at American Fork Junior High had only one female student. As an elective program it was important to maintain enrollment and provide opportunities for all students in the school to participate in technology and engineering classes. Increasing female enrollment was identified as an area where this elective program could grow. Some research was done by looking at other schools in the school district and the state, and it was determined that some schools were increasing female participation by organizing all-female classes or classes that attracted female interest as early as the 7th grade. Two schools in Alpine School District had “Girls with Tech” classes and another school in Salt Lake City had a “Pinterest Projects” class to increase female interest. After getting approval from the administration, American Fork Junior
High then offered for the first time an all-female class Exploring Technology 7th grade class called “Women in Engineering” in the 2017-2018 school year.

The basic premise in creating the class was to provide female students an opportunity to sign up for “all-female” sections of the Exploring Technology class and then introduce them to technology and engineering curriculum that was focused on designing and creating solutions to engineering problems. In this study, all students in the control and treatment groups were presented with design problems in units of instruction related to robotics, communications, power and energy, manufacturing, etc. with the hope that this focus on design might create a greater interest in technology and engineering which would lead to increased female student enrollment. Figure 5-1 provides a basic overview of the rationale for offering the all-female sections of the class. The conclusions to the various research questions, based upon data collected from the TEAS and DAET, are presented in the following sections.

![Figure 5-1: Rationale for Increasing Female Student Enrollment]

5.2 Interest in Learning About Technology and Engineering

From the results of the TEAS pre-survey at the beginning of the semester, we found that the female students indicated that they were generally interested in learning about technology and engineering. This was not surprising in that they had signed up for a technology and engineering elective course. After participation in the treatment, these female students indicated decreased levels of interest on each of the survey items resulting in the conclusion that they were
significantly less interested in learning more about technology and engineering at school at the end of the semester when compared to the beginning of the semester. Additionally, large standard deviations in the post-test data indicate a possible polarization of the female students regarding interest in learning about technology and engineering.

### 5.3 Interest and Enrollment Increase

When the data on female student interest in learning more about technology and engineering was analyzed, researchers were surprised to see a negative shift in female students’ interest scores. The general indication during the semester was that the students in the all-female class were actively participating in class activities and a positive shift in interest was anticipated. A rational for this negative shift in interest was hypothesized. Could it be that given the tenuous situation of the pandemic, and female students not being able to fully participate in class activities, that they indicated less-positive perceptions? Could it be that the female students’ interest in all education-related activities and subjects was less positive because of the changing school dynamics given the pandemic environment? Maybe the activities during the semester were not as enjoyable to the female students as they expected when they signed up for the class? To further investigate female student interest, researchers determined to examine female student enrollment patterns as another indication of female student interest in learning more about technology and engineering.

While the data from the TEAS indicated that female student interest in learning about technology and engineering significantly decreased from the beginning to the end of the treatment, enrollment data obtained from the school administration shows that since the creation
of the all-female 7th grade Exploring Technology class in 2018-2019, that female enrollment in technology and engineering classes has increased as shown in Table 5.1.

Table 5-1: Class Enrollment Data

<table>
<thead>
<tr>
<th>Year</th>
<th>7th</th>
<th>8th</th>
<th>9th</th>
<th>Population</th>
<th>Exploring Technology 7th Grade</th>
<th>Engineering Technology 9th Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
<td>Male</td>
<td>Female</td>
<td>Total</td>
</tr>
<tr>
<td>2016-2017</td>
<td>623</td>
<td>680</td>
<td>631</td>
<td>1934</td>
<td>216</td>
<td>60</td>
</tr>
<tr>
<td>2017-2018</td>
<td>679</td>
<td>640</td>
<td>640</td>
<td>1959</td>
<td>238</td>
<td>59</td>
</tr>
<tr>
<td>2018-2019</td>
<td>659</td>
<td>657</td>
<td>633</td>
<td>1949</td>
<td>276</td>
<td>118</td>
</tr>
<tr>
<td>2019-2020</td>
<td>668</td>
<td>653</td>
<td>664</td>
<td>1985</td>
<td>276</td>
<td>140</td>
</tr>
<tr>
<td>2020-2021</td>
<td>608</td>
<td>673</td>
<td>674</td>
<td>1955</td>
<td>227</td>
<td>116</td>
</tr>
<tr>
<td>2021-2022*</td>
<td>629</td>
<td>632</td>
<td>679</td>
<td>1940</td>
<td>255</td>
<td>123</td>
</tr>
</tbody>
</table>

*Projected based off enrollment May 2021

Note that prior to the all-female class there were 60 female students enrolled in Exploring Technology in 2016-2017 and 59 in 2017-2018. Female enrollment increased 200% in 2018-2019 to 118 female students and has continued to remain at 116-140 students with a projected enrollment in 2012-2022 of 123 female students.

In addition to the increase of female students taking the 7th grade Exploring Technology course, the numbers of female students choosing an advanced 9th grade technology and engineering course also increased since the 2018-2019 school year. In 2017-2018, the 9th grade Engineering Technology class only had one female in it. This number increased to 14 in 2020-2021 which was the first 7th grade group to be offered an all-female option. It is projected that in
2021-2022 that there will be 12 females enrolled in the 9th Engineering Technology class. It was noted in the findings, that the large standard deviations on the post-test of the interest section of the TEAS indicated variability in the interest in learning more about technology and engineering construct. One possible explanation is that while the overall class scores indicated less interest, there was a polarization effect on other female students who determined more interest in the subject resulting in them signing up for additional classes and thus the increased enrollment witnessed since the creation of the all-female technology and engineering classes.

5.4 Interest in a Career in Technology and Engineering

In the second section of the TEAS, it was investigated whether female students were interested in having a career in an engineering or technical field. At the beginning of the semester the female students in the treatment indicated that they were neutral about potentially having a career in technology and engineering. At the end of the semester, these same female students indicated slightly less interest in a technology and engineering career but none of the survey items were statistically significant resulting in the conclusion that female students’ interest in a career in technology and engineering remained unchanged after participation in the treatment of being group with the only females.

5.5 Perceptions of Gender Roles and the “Cushion Effect”

From the TEAS subscale on gender roles in technology and engineering researchers discovered some intriguing results. At the beginning of the semester, the all-female classes in the treatment group strongly agreed or agreed that females could be successful in the fields of technology and engineering and strongly disagreed to disagreed that boys were better at
technology and engineering or knew more about it than girls. At the end of the semester, the all-female classes remained constant in their perception that females could successfully participate in technology and engineering activities.

Interestingly, for the females in the control group, we saw a big change in their perception that females could successfully participate in technology and engineering activities. From the pre-test to the post test, there was an overall decrease in their positive perceptions along with large standard deviations in their mean scores indicating that there might have been some polarization of the females in the mixed male-female classes on their perception that females could successfully participate in technology and engineering activities.

Given that there was no real change in the treatment group and that the control group changed dramatically in their perceptions, we can see the treatment might have influenced female students’ perceptions based upon their grouping in an all-female class or with a male-dominated class. We call this finding the “cushion effect.” It might appear that by being in a mixed class, girls decided early on in their experience that they either really liked technology and engineering, or they disliked it. By being grouped in an all-female class attitudes were unchanged, protected, or cushioned.

One possible indication of this “cushion effect” is the observed increased enrollment for female students in successive technology and engineering classes. This was an observed increase in female participation after the creation of the all-female classes in 2017-2018. It is possible that by having the females and males grouped together in a common technology and engineering class that it may have deterred many of the females from taking additional technology and engineering courses in future semesters.
5.6 Perceptions of What an Engineer Does and Looks Like

From the first administration of the DAET at the beginning of the semester, we can see that both the students in the control group and treatment group, had perceptions that an engineer was someone who fixes and builds things and that a majority of students also indicated engineers as males. On the post-test administration of the DAET at the end of the semester, the male students in the control group had a slight shift of perceptions of an engineer from building and fixing to someone who is involved with the design of solutions. Their perception of engineers as males was also less pronounced in the post-test with many of them drawing gender neutral drawings of engineers. The perception of engineers as persons that build and fix things is consistent with the observations of the instructor while working with the students throughout the course. The instructor observed repeatedly that when given a design problem the males in the class were mostly focused on building and fixing things and often hurried through the design aspects of the activity.

Through the course of the semester, the all-female treatment group had two shifts in their concept of engineers that were worth mentioning. First, from the pre-test to the post test, they shifted from the majority (61%), indicating that an engineer was someone who builds and fixes things, to only 31% on the post DAET. Coincidently, there was a large shift from 25% to 49% of the female students that indicated that an engineer is someone that designs. Hopefully, this can partially be attributed to the design-focused curriculum presented in the Exploring Technology class and that females are more attracted to design over building and fixing things.

The second shift was an increase of female engineers being represented on the drawing of the post DAET by the students in the all-female classes. A change from 25% of the student in the
all-female classes drawing female engineers to 62% of these same students drawing female engineers was observed from the pre-post administration of the DAET. This provides some indication that the females in the treatment group can see themselves or other females as engineers. The curriculum taught in both the control and treatment classes remained constant. However, by being grouped with all females there is some indication that the females in the treatment changed their perceptions from a mostly male dominated career to a more female one.

5.7 Limitations

In this study there are several possible limitations. The first was that this study was completed during the COVID-19 Pandemic. Because of the pandemic, some classes were shortened, and some students were not able to participate in all the activities the course traditionally offers. This also resulted in many students missing classes for extended periods of time because of quarantines and exposure to the virus. Another limitation is that the initial high scores on the TEAS could have produced higher than average starting scores because of the students’ initial excitement of returning to a more traditional school system instead of their online schooling which took place at the end of the previous school year. It would be interesting to compare students’ indication of interest of their other classes taken during the pandemic.

Another limitation to this study was that fluctuating attendance gave us a limited n-size. More students were in the class but were unable to be a part of the study because of the reasons described above. To run the study again at multiple schools would help increase the n-size and increase the generalizability of the findings. The researcher in this study was also the instructor which could have biased the class opinions toward engineering and technology. Another compounding factor with the instructor was that he was male, and this might have impacted their
concept of an engineer on the DAET as some students even drew the male instructor on the DAET. This would be consistent with other research studies which have shown that the gender of the instructor does influence their perceptions of students (Jensen, In press).

5.8 Possible Future Research

As mentioned previously, this study was completed during a pandemic year. The first recommendation for further research would be to complete a similar study in a non-pandemic school year when students can fully participate in the technology and engineering activities that are part of the class. Conducting the study in multiple schools with teachers of both genders would also be recommended to increase generalizability of the findings and to investigate the impact that the gender of the teacher might have on the study. Finally, a qualitative investigation of the female students that have chosen to take additional technology and engineering classes at the 9th grade would be recommended to determine the contributing reasons they chose to learn more about the subject.

5.9 Summary

The purpose of this study was to investigate potential changes in female students’ concept of, and interest toward, technology and engineering when allowed to participate in an all-female technology and engineering class. Through an analysis of the data, we were able to conclude that while providing the female students the opportunity to sign up for and participate in an all-female class resulted in many of these students reporting less interest in learning more about technology and engineering, other female students became more interested in learning more about technology and engineering as evidenced by the increase in enrollment in later
classes. In addition, participation in the treatment did not significantly change female students’ interest in a career in technology and engineering. Finally, in regard to gender roles and the perception of females’ ability to participate in technology and engineering, there seems to have been a “cushion effect,” that, took place in which those in the all-female classes kept their positive perceptions while the female students that were in the mostly male classes reported less positive perceptions.

Additionally, an analysis of the data allowed researchers to conclude that participation in the treatment had a significant impact on female students’ perception of what an engineer is and what an engineer does. All students, but especially those in the all-female classes, were more able to see that engineering is more about designing than building and fixing things and that their perceptions of engineers shifted from that of mostly male to mostly female. Potentially this means that they could see themselves as engineers in the future.
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APPENDIX A. THE TECHNOLOGY AND ENGINEERING ATTITUDE SCALE

TEAS

Circle your class period: A1, A2, A3, A4, B1, B2, B3, B4
Circle your gender (M, F)

The following questions were made to determine what you think about engineering and how you feel about it. Read each statement carefully, and respond with honest feedback. 1 is strongly disagree, 2 is disagree, 3 is neutral, 4 agree, 5 strongly agree. Note: electronic likert scale provided on actual TEAS

1. I am interested in technology and engineering
2. Boys are better at being engineers than girls
3. Engineering and technology has nothing to do with our lives
4. To be good at engineering or technology you have to be very smart
5. Engineers and technologist solve problems
6. I think engineering and technology is often used in science
7. Engineers and technologist help make people’s lives better
8. Girls can be as successful doing engineering and technology as boys
9. I am good at problems that can be solved in many different ways
10. I would like a job that lets me do a lot of engineering and technology
11. Engineers use a lot of math and science
12. I think I could do well in an advanced technology and engineering class
13. I think that having a job in engineering or technology would be fun
14. I think there should be a class at my school related to technology and engineering
15. I would be nervous to take a technology and engineering class
16. Science has nothing in common with technology and engineering
17. I would like to be a technologist when I grow up
18. You have to problem solve to be an engineer or technologist
19. I would like to learn more about technology and engineering at school
20. If there was a technology and engineering club at my school, I would like to join
21. A girl can have a technical job
22. In my everyday life, I am good at solving problems
23. I would like to be an engineer when I grow up
24. World problems, like water and air pollution, influence the jobs of technologist and engineers
25. Solving problems is hard
26. Technology and Engineering has brought about more bad things than good things
27. To me, the field of science is related to the field of technology and engineering
28. Working in engineering and technology as a job would be boring and dull
29. Engineering and technology makes our lives more comfortable
30. When I think of engineering and technology, I mostly think of solving problems
31. To become an engineer or technologist, you have to take hard classes
32. Boys know more about engineering and technology than girls
33. You don’t have to be smart to study engineering and technology
34. In engineering and technology, you use math
   More targeted questions toward American Fork area
35. I plan to take additional classes in high school that will prepare me to become a technologist
36. I plan to take additional classes in high school that will prepare me to become an engineer
37. I am interested in joining the Technology Student Association Club at our school and participating in technology and engineering competitions with students from other schools.
38. I am interested in taking more technology and engineering classes here at American Fork Jr High
39. I am interested in taking more technology and engineering classes here at American Fork Jr High
40. I am taking this class because I want to be an engineer
41. I like engineering so I took this class

Subscale for the TEAS

Interest in Learning
   1, 12, 14, 15, 19, 20
Interest in a Career
   10, 13, 17, 23, 28
Importance and Contribution to Society
   3, 7, 24, 26, 29
Difficulty
   4, 31, 33
Relationship to Math and Science
   6, 11, 16, 27, 34
Gender
   2, 8, 21, 32
Connection to Problem Solving
   5, 18, 30
Problem Solving Capability
   9, 22, 25
## Appendix B. Coding Instrument for the Draw an Engineer Test

### DAET Rubrics

<table>
<thead>
<tr>
<th>Grouping Rubrics</th>
<th>Thematic Grouping Images Included in Group Occurrence of Image</th>
<th>Total (tally below)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Images of Building/Fixing</strong></td>
<td>Tools, Hard Hat, Workbench, Safety Glasses, Heavy Machinery</td>
<td></td>
</tr>
<tr>
<td><strong>Images of Designing</strong></td>
<td>Desk, Plans or Blueprints, Pen/Pencil, Models, Computers</td>
<td></td>
</tr>
<tr>
<td><strong>Images of Products of Engineering - Mechanical</strong></td>
<td>Cars, Engines, Machines, Rockets, Airplanes, Robots</td>
<td></td>
</tr>
<tr>
<td><strong>Images of Products of Engineering - Civil</strong></td>
<td>Bridges, Roads, Buildings, Houses</td>
<td></td>
</tr>
<tr>
<td><strong>Images of Trains</strong></td>
<td>Trains, Train Tracks, Train Engineers</td>
<td></td>
</tr>
<tr>
<td><strong>Images of Laboratory Work</strong></td>
<td>Test Tubes, Beakers</td>
<td></td>
</tr>
</tbody>
</table>

*Figure B-1: Type of Engineer*
### Determining Drawing Gender Rubric

<table>
<thead>
<tr>
<th>Male</th>
<th>Female</th>
<th>Undetermined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial Hair</td>
<td>No Facial hair</td>
<td>No Facial Hair</td>
</tr>
<tr>
<td>Short Hair</td>
<td>Long Hair</td>
<td>No hair</td>
</tr>
<tr>
<td>Big Muscles/Lack of breasts</td>
<td>Smaller Muscles/Breasts</td>
<td>Stick Figure</td>
</tr>
<tr>
<td>Male Clothing</td>
<td>Female clothing</td>
<td>Both sex characteristics</td>
</tr>
<tr>
<td>Defined facial features</td>
<td>Soft facial features</td>
<td>Not human</td>
</tr>
<tr>
<td>Arm/Leg hair</td>
<td>Not hairy</td>
<td></td>
</tr>
<tr>
<td>Male Name</td>
<td>Female Name</td>
<td>No Name</td>
</tr>
</tbody>
</table>

**Figure B-2: Gender Determination**