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An Investigation of Middle School Student Interest, Perception, and Attitude Toward Technology and Engineering

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AN INVESTIGATION OF MIDDLE SCHOOL STUDENT

INTEREST, PERCEPTION, AND ATTITUDE TOWARD

TECHNOLOGY AND ENGINEERING

by

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ABSTRACT

AN INVESTIGATION OF MIDDLE SCHOOL STUDENT INTEREST, PERCEPTION AND ATTITUDE TOWARD TECHNOLOGY AND ENGINEERING

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The purpose of this study was to investigate middle school student perception and attitude toward technology and engineering and to better understand how the gender of the teacher, gender of the student, and information provided in technology classes affected their perception and attitude. To accomplish this, the Technology Attitude Scale, and the Pupil's Attitudes Toward Technology—United States assessment instruments were used to form the basis of a new survey instrument focused on technology and engineering perception, use, and interest. The new survey instrument is called the *Technology and Engineering Attitude Scale (TEAS)* survey. Multiple 7th grade technology engineering classes from four different schools in Utah were included in the study. The student survey responses during the first two weeks and last two weeks of

their technology engineering class were triangulated with qualitative information gained from class visit and interviews to better understand their conception and attitude to technology and engineering. A key finding was that male students showed higher learning and career interest at the onset, while the female students' interest increased significantly over the term of classroom instruction.

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1 Introduction

Technology Education is an essential component of school curriculum. Since its inception and throughout its evolution, there have been people who have argued that technology education should be included as a core general education requirement, while others maintain it needs to remain an elective and prepare students for specific vocations (Prakken, 1976).

The motivation to include technology education as a core requirement of general education requirements stems from the need to ensure that all students be literate in technology (International Technology Education Association, 2000). The movement focused on technological literacy was the most significant factor in the title and curriculum shift from Industrial Arts to Technology Education in the 1990's (Boser, Palmer, Daughtery, 1998). The technology literacy curriculum of the nineties expected students to develop the ability, understanding, and skills to use, manage, assess, and understand technology (International Technology Education Association, 2000).

Recently, the definition of Technology Education is again changing. Its current focus is on the inclusion of engineering concepts in K-12 curriculum (National Center for Engineering and Technology, 2007). This shift is evidenced by the name change in Massachusetts from Technology Education to Engineering with Technology (Massachusetts Department of Elementary and Secondary Education, 2009), and

Technology and Engineering Education title in Utah and Tennessee (Utah State Office of Education, 2009 and Tennessee Department of Education, 2009). Many states without a change in title often include engineering concepts in the curriculum. For example while Mississippi calls the subject *Technology Education*, engineering is clearly described in the mission statement. :

"The knowledge base learned through technology education is important to everyone as all members of society must continually learn in a changing society that is influenced by technology. It provides for academic, technical, and social growth through involvement with tools, machines, materials, and systems of technology. It enables all students to derive meaning from concrete experiences that result from the integration of mathematics, science, humanities, and ***engineering*** concepts." Emphasis added (Mississippi Department of Education, 2009).

Title changes in various technology education courses have influenced content and curriculum. The new technology and engineering focus includes a broader skill set and focus, suggesting technology education needs to keep up with the world's business and economic engineering and technology focus. The National Academy clarifies this perspective:

"In its broadest sense, technology is the process by which humans modify nature to meet their needs and wants. …technology is more than its tangible products. An equally important aspect of technology is the knowledge and process necessary to create and operate those products, such as ***engineering know-how and design***, manufacturing expertise, various technical skills, and so on." Emphasis added. (Committee on Technical Literacy, 2002)

1.1 Statement of Problem

In result of the recent technology education curriculum and objectives modifications, there was a need to understand the influence of these changes on the students. The Technology Attitude Scale (TAS) (Jeffery, 1993) and Pupils Attitudes Toward Technology (PATT) (de Vries 1985), have been used to ascertain students' attitude toward and understanding of technology. However, these tools do not include the current emphasis in engineering issues. Thus a comprehensive instrument was needed to measure students' perception, attitude, and understanding of both engineering and technology. Through this research study a survey tool was developed titled, *the Technology and Engineering Attitude Scale (TEAS)*, based on the TAS and PATT-USA (de Vries, 1996)to accomplish this goal. In addition to survey development, the surveys were implemented and companion class visits were conducted in order to ascertain student's perception and attitude towards engineering and technology.

1.2 Research Questions

The main research questions investigated included:

- Do female teachers have a stronger effect on female students' perception and attitude towards engineering and technology than male colleagues?
- Do male students have greater understanding of and a more positive attitude towards engineering and technology than female peers?
- Do students perceive a connection of engineering and technology with science, math, society, and/or problem solving?
- Are students interested in learning about or having a career in engineering and technology?
- Do students perceive engineering and technology as difficult curriculums?

1.3 Method of Data Collection

The data was collected in two main formats. The first one was based on answers to the *Technology and Engineering Attitude Scale (TEAS)* survey instrument. A panel of experts reviewed the TEAS for face validity and age level appropriateness before the survey was given to the students. Informed consents were requested from all participating students and their parents. The surveys were given to the students during the first two weeks (Pre) and again in the last two weeks (Post) of the Technology rotation of the 7th grade Introduction to Career and Technical Education Technology Course by their teacher. The second data format was qualitative. Follow up class visits including observations of the class, teachers, and students as well as informal interviews with the students and teachers were conducted to triangulate survey responses and validate the results.

1.4 Method of Data Analysis

Responses from the survey were grouped and an effect size was used to determine practical significance of the survey response differences in the categories that the survey investigates. For each category the comparison groups included:

- Class to class
- Female students to male students
- Students with female teacher to students with male teacher
- Female students with female teacher to male students with male teacher
- Female students with male teacher to male students with female teacher

Interview responses were analyzed for patterns and themes using a simplified version of Spradley's Qualitative Analysis technique (Williams, 2009). Chapter three details the analytical methodology.

2 Review of Literature and Research

2.1 Student Perception of Engineering and Technology

2.1.1 Student concept of and attitude towards Technology

Numerous researchers have investigated student interest in technology. Notably Raat and de Vries found, while using the Pupils' Attitude Toward Technology Scale (PATT), that student technological attitude was primarily influenced by: (i) interest in technology, (ii) perception of gender differences, (iii) diversity of technology, and (iv) importance of technology. In addition, the main conclusions showed students' conceptions of technology were vague, and females were less interested in technology and found it less important than their male peers (Raat and deVries, 1985). When the PATT was modified for the United States in 1989 (PATT-USA), Bame and Dugger found that students were generally interested in technology and males yielded greater interest than females. Additionally, females seemed to have a stronger belief that technology was appropriate for students of both genders than their male peers. (Bame and Dugger, 1993).

In 1998, a Pre and Post survey of middle school students in technology classes looked at the students' attitude and perception/definition of technology (Boser, Palmer, and Daughtery, 1998). Research evaluated different teaching approaches including:

1. “Industrial Arts Approach: A body of related subject matter, or related courses, organized for the development of understanding about all aspects of industry and technology, including learning experiences involving activities such as experimenting, designing, constructing, evaluating, and using tools, machines, materials, and processes (American Council on Industrial Arts Teacher Education, 1979).
2. Integrated Approach: Instruction that incorporates other disciplines such as English, math, science, and social studies to show how technology is an integral part of other disciplines and vice versa. It also emphasizes the need for humans to apply knowledge from other disciplines to solve technological problems.
3. Modular Approach: Individualized, self-paced, action-based units of instruction that allow students to use current technologies to learn independently. The modular approach provides students with problems and activities that encourage them to use critical, higher-level thinking skills to solve problems and make value decisions.
4. Problem Solving Approach: An instructional approach that emphasizes critical thinking and is centered around students using a problem solving process to find creative solutions to problems that are technological by nature.”

The research suggested that student attitudes became significantly more positive only for integrated and modular approaches, and the understanding of technology’s consequences only increased from integrated approaches. The industrial arts and problem solving approaches to technology education seemed to leave the students without significant changes in attitude or conception. In addition to evaluating Pre and Post survey results based on teaching approaches, researchers investigated gender and found gender differences—females viewed technology as a difficult curriculum, had less general interest in the topic, and perceived that technology was appropriate for males and females.

The children’s attitude toward technology scale (CATS*) research concluded that males were more interested in technology (Frantom, Green, and Hoffman, 2002). However in contrast to the PATT-USA results (deVries, 1985), the CATS* research suggested that males had higher confidence in females’ use of technology than the females did in themselves. While, there was minimal discussion of this difference, the study of teaching approaches mentioned above could be a lurking variable in the study if the teaching style was tailored toward the male learning styles. In addition, other factors such as culture, parents, and behavior of the teacher could have had an effect.

The gender effects on elementary-aged students' interest in technology have been studied. One study suggested that the student's interest towards things associated with technology varies based on gender. Male student perception of which objects associated with technology are of highest interest varied during elementary school. Contrastingly the females, who seemed to have consistent views on what objects associated with technology were of most interests, had varying perception of what was least interesting (Stwalley, 2007).

2.1.2 Student Concept of and Attitude Towards Engineering

A similar study has been done to ascertain students' attitudes toward engineering. One study investigated the effects of pre-engineering courses on students (Hirsch, Carpinelli, Kimmel, Rockland, and Bloom, 2007). It showed that exposure to engineering led to significant increases in understanding of what engineers really do, interest about the role of engineering in society, and student confidence in solving problems when compared with non pre-engineering students.

2.2 General Public Perception of Engineering and Technology

Having discussed the students' perspectives, it was also important to understand the perceptions held by people in general. This understanding provided the framework from which students' perceptions and attitudes were influenced. The framework of general perception potentially provided influences into the responses found during the Pre-class surveys in this study.

2.2.1 Relationship between Engineering and Technology

There is overlap between engineering and technology. University students that study technology take many of the same courses as those that study engineering (i.e., math, science, and technical communication). Accordingly, they both work from a similar foundational knowledge.

The distinction between engineering and technology results from the tools used. While technologists and engineers both use theoretical and physical tools, technologists tend to focus on practical experience with physical tools and machines for teaching and design, while the focus of engineering tools center on mathematical, scientific, and analytic tools (Merrill, 2006). Lewis describes the difference in this way:

> "What distinguishes the engineer from the technician is largely the ability to formulate and carry out the detailed calculations of forces and deflections, concentrations and flows, voltages and currents that are required to test a proposed design on paper with regard to failure criteria." (Lewis, 2005)

Another way to look at the relationship between engineering and technology is to compare the following definitions (Pearson, 2004).

- <u>Engineering Education</u>—high barriers to entry, focus on theory and analysis, large number of practitioners, training for research and practice, established discipline, established content, technological literacy is seen as being of minor importance to field.

- Technology Education—low barriers to entry, focus on practical/hands on, small number of practitioners, training for teaching, evolving content, technological literacy is seen as main justification for the profession.

Based on these perspectives, integrating engineering into technology curriculum at the foundational level of K-12 allows for a workable blend of the different tools and processes, and provides students the opportunity to use both learning strategies — physical and theoretical.

2.2.2 Perception of Professional Technologist and Engineers

Both engineers and technologists have made important advances. With these advances comes the responsibility to be open and informative about the technical implications toward environmental, health, safety, and economic factors (Wulf, 2002).

Despite the recognition of the importance of technology and engineering, it is surprising that the public overlooks the humanistic side. Many people define humanitarian related occupations as careers focused on helping people (i.e., doctors, teachers, and lawyers) and fail to recognize a need to include engineering and technology related professions. This inclusion is warranted since engineers and technologists by definition have a mission of helping people through solving problems, providing services and infrastructure, and meeting the needs of society (i.e., power, water, communication, transportation, and security/protection). In further confirmation of this disconnect, surveys specifically comparing scientist and engineers found that engineers were only one-fourth as likely to be associated with "improving the quality of life" and only one-tenth with "saving lives" (Pearson, 2004).

2.3 Importance of Technological Literacy

Engineering and technology are intertwined with society and with each other. Unfortunately, members of society do not always understand engineering and technology and the involvement within society to provide services and goods. In fact, at times, people were confident in the lack of understanding and felt that it was acceptable with no need for striving to develop an understanding. For example, professors of computer science engineering when discussing their career receive comments such as “Oh, I don’t understand that stuff.” Would it be acceptable for a technologist or engineer to respond to one who has a profession in English with similar pride in their lack of understanding English (Wulf, 2002)?

The perception of technological illiteracy as acceptable is not the norm nor is it completely the fault of those who do not understand. Current young people are generally literate with computers, web knowledge, and experiences, because of being raised with continuous interactions with technology. Those without such interactions are not being judged, but the case stands that those with higher technological literacy have greater openness of attitude to learn, experience, and see the benefits of technology. In contrast, those without similar technological literacy often maintain low confidence and priority toward learning about technology. These simple examples of differences in the perceptions of technology within society depict the important need for technological literacy.

2.3.1 General Understanding of Technological Literacy

Regardless of the perception people have of engineering and technology, it is not sufficient to only implement the use of technology. The incorporation of technology within society requires that people make personal and community decisions about the risks, economics, standards, and tradeoffs (Gorham, 2002). As members of community, government, and family; leaders need an understanding of technology to make informed socio-scientific and ethical decisions, to continue to guide constituents in the forefront of using technology to meet society's needs, and to prevent exclusion and/or manipulation (Carulla, 2007). In support of society's understanding the implications of technology, Siler et al stated:

"How can a person reasonably vote in an election on issues such as 'Star Wars Defense System,' 'human cloning,'…etc. without having general background knowledge in engineering and technology? Unless action is taken, we are at a crossroads where citizens can be trained to do a skilled job but not understand the benefits or consequences of using present or future technology rationally and responsibly." (Siller et al, 2007).

2.3.2 Concerns within Education

Considering the need for technological literacy defined, large steps have already been taken to integrate technological literacy into school curriculums. For example, consider Massachusetts Recommended Pre K – 12 Instructional Technology Standards (Massachusetts Department of Education, 2001). On a national level, the "No Child Left Behind" program calls for enhancement of education through technology and increased technology funding (United States Department of Education, 2009)). However, there is still much progress to be made.

Added complications to attaining technological literacy come through integration of engineering into technology standards. There is a concern that integrations means an absolute focus on pre-engineering in preparation for college engineering degrees creating a loss of educational value to 80% of high school graduates who do not attend college. Yet, this is not the case. Jerry Yeargan, 2001 President of Accreditation Board for Engineering and Technology, stated that "establishing Standards for Technological Literacy is *not* about getting more students into engineering; it is about getting the right students into engineering" (Gorham, 2002 emphasis added). In other words, it is not about changing someone who is best fit for a vocational or other path, but rather presenting the often neglected opportunity of an engineering path to those who are well fit and interested. In addition, incorporation of engineering into technology education allows a more informed and better problem solving public that has been exposed to both technology and engineering.

2.4 Gender Differences in Engineering and Technology

In order to maximize the implementation of engineering and technology skills to meet the needs of society, those that have skills and interest well suited for engineering and technology (including females) need to be presented with the opportunity. Maximizing engineering and technology to meet the needs of society is essential to provide mediums of communication, advances in medical procedures, address environmental sustainability, and improvements to defense tactic. The current demand for engineers and technologists in the job market along with low involvement of females makes increasing females' involvement of added importance to increase the capacity to meet current needs and provide diversity and perspective in finding engineering solutions (Wulf, 2002).

2.4.1 Gap in Involvement

The percentage of engineering Bachelor's degrees being awarded to females in 2005-2006 hit a low of 19.3%, lowest since 1998 (Stwalley, 2007). Engineering technology degrees show even smaller portions of degrees received by females— at 10 percent. The main trends in enrollment can be seen in data collected by the American Society of Engineering Education for a 2005-2006 report (Gibbons, 2006) as shown in Figures 2-1 and 2-2.

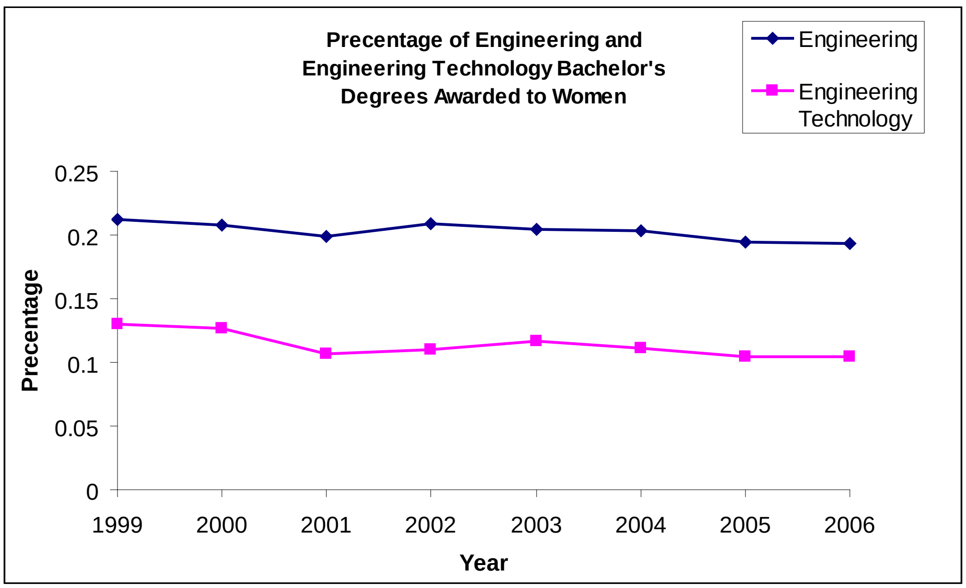

Figure 2-1: Percentage of engineering and engineering technology Bachelor's Degrees award to women from 1999 to 2006

Figure 2-1 shows the percentage of Engineering (blue line/diamond marker) and Engineering Technology (pink line/square marker) bachelor's degrees awarded to females from 1999 to 2006. The percentages are steady and nearly parallel each other with about an 8% difference—engineering being higher. It is important to note that the percentage of all bachelor's degrees (all majors) being awarded to females is also constant around the 50% level. Thus, these percentages depict a slight decrease in female engineering/technology graduates not an effect confounded by an overall change in bachelor degrees awarded to women. In addition, the disparity between genders is not a product of college graduate gender disparity (Ohio Board of Regents, 2003).

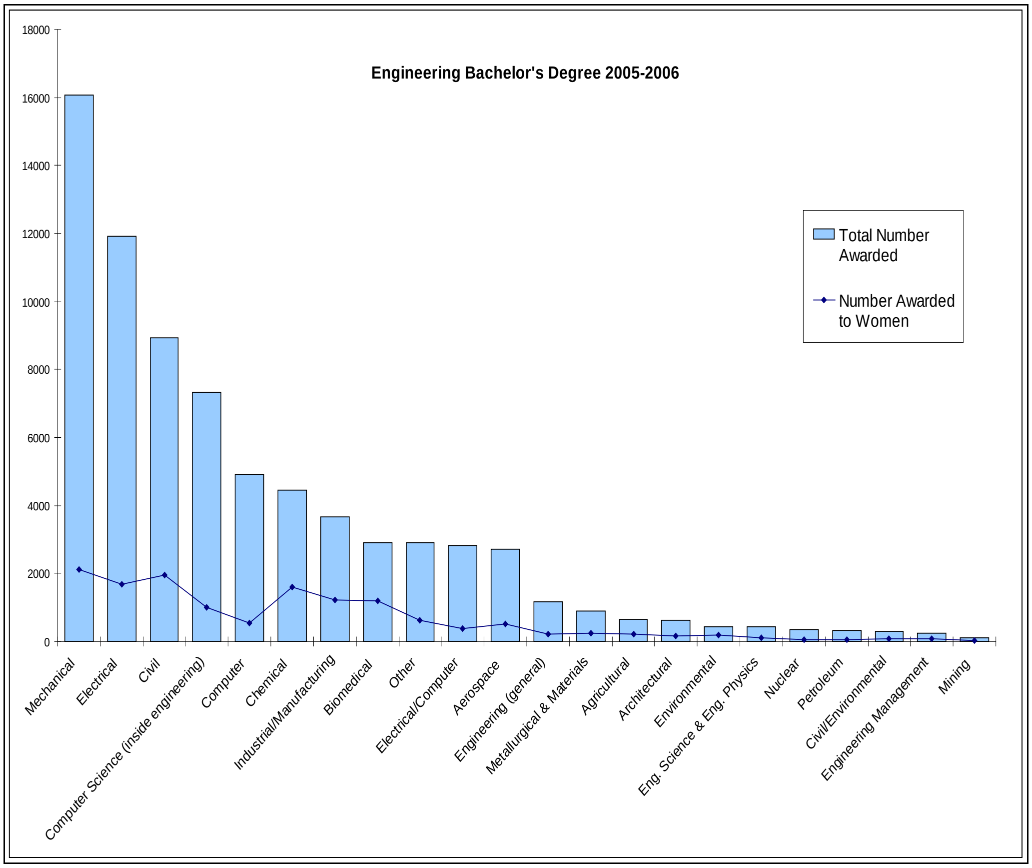

Figure 2-2: Breakdown of Engineering Bachelor's Degrees (Bar graph shows total number of degrees. Line depicts number of degrees awarded to females).

In Figure 2-2, the bars show the total number of engineering bachelor degrees awarded by discipline with the line detailing the number awarded to females. It is not clearly established, but the peaks in the female awards for civil and chemical engineering may have resulted from the inclusion of environmental and biomedical respectively at many universities. On the other hand, it might represent an affectively appealing combination of discipline exposure that allows women to find interest in a wide range of engineering opportunities.

2.4.2 Attitude

The low percentage of females in engineering and engineering technology may be tied to student perception, societal perception, and / or the tradition of sexual segmentation in the workforce. Some students perceive the gender disparities within the workforce as stereotypes which must be followed. A decrease in the perceived need to follow stereotypes occurs in the late elementary (6^{th} grade) through middle school years (9^{th} grade) (Cummings and Taebel, 1980). The stereotyped attitudes might resurface during high school causing constrained career aspirations based on their gender-role socialization (Warren, 1990). These findings suggest that late elementary (6^{th} grade) through middle school years (9^{th} grade) is the greatest opportunity for influence of female's perception of career gender-appropriateness without bias tied to workforce stereotypes.

There are gender differences of interest in technology and in perception of females' skills toward technology as discussed in the student perception section, 2.1.1, (Frantom, Green, Hoffman, 2002). Further studies have looked at the influences on these differences which found that involvement in a class or summer experience influences students' attitude towards the topic of the experience. One study found that females were more strongly influenced by such experiences than the males (Lee, 2002). A survey of 300 high school and college females about their interest in Information Technology using a 167 item Likert-scale survey, found that students are highly influenced by their parents (Burger, 2007). An additional study found that school teachers have a less significant influence than parents on female students' career choice. This particular study also showed that females and males perceive similar control over their career choice

(Kniveton, 2004). In addition, gender-related barriers to career decision include perception of gender discrimination and potential work-family conflicts (Lopez, 2006).

Efforts to address these attitude differences have resulted in change. For example, females now say “I know I can do it, but I just don’t want to,” rather than saying they do not knowing anything about engineering and technology or they feel unconfident in their engineering and technology abilities (Burger, 2007). This suggests that the gender differences in perception of ability and understanding is changing.

2.4.3 Capability

Student class performance has often been studied to display capabilities in particular areas and evaluate gender difference in capability. Even though class performance grades may reflect other factors than capabilities such as motivation to study, and determination to follow teacher instruction; grades are the most common performance measure. One particular study of students enrolled in a freshman level engineering class (approximately 50/50 gender split) found that females did as well or better on all class assignments other than the final project and received a higher average grade in the class (Orabi, 2007). Noting the other confounding factors of class grades, this cannot be used to show gender superiority, but it does depict female capability.

In addition, brain, hormone, or cognitive development studies have not found significant biological differences between performance of males and females in science and mathematics (Committee on Maximizing the Potential of Women in Academic Science and Engineering; Committee on Science, Engineering, and Public Policy, 2007). Thus the gender differentiation in attitude and involvement has not been explained by actual physical gender differences.

2.4.4 Enrollment and Retention

There have been arguments discussing whether the gender gap is tied most closely to enrollment or retention. Studies have been done to investigate the role of both.

Efforts to increase females' advancement into faculty engineering roles at the university level had two main influences. One is the level of recognition provided to students; females with a female advisor were the only students that perceived that they received appropriate recognition (Gallaher, 2000). The second was in providing a female faculty engineering role model rather than a mentor—someone to easily select and reject attributes from to create an ideal example to follow (Gibson, 2004). Even with this and other help to female student retention, there has not been a significant change in engineering female enrollment and retention.

The lack of change in enrollment numbers for female engineering and technology students could be due to the decision to enroll in a specific major being made before college. The decision is made during high school years with experiences in even earlier middle and elementary school effecting the decisions. One study used a career expectations questionnaire of high school students at a career fair to investigate student career choices. The research concluded a need to increase females' positive expectations of engineering and introduce them to engineering early in their school career (Blaisdell, 2000). This can be done through math, chemistry, and biology high school courses, because girls are as likely as boys to take typical high school math classes and slightly more likely to take biology and chemistry. Even before high school, introducing engineering and technology as creative and applicable will likely increase interest (Thom, 2001). This can be done at every grade level, K-12, as is being done in Massachusetts

(Massachusetts Department of Elementary and Secondary Education, 2009). Increasing enrollment also ties back to public perception and the need for teachers, guidance counselors, and society to have a positive perception of technology and engineering as an exciting career with a positive impact on humanity (Loftus, 2007). In general, in order to make an impact on enrollment, continued education and collaboration between students, educators, counselors, and legislators are needed regarding the importance of engineering and technology (Merrill, 2006).

2.5 Multidisciplinary Learning

Having established technical capability, it is appropriate to look into different teaching approaches such as multidisciplinary learning to allow students to make broader connections of engineering and technology with other academic disciplines that do not have gender disparity.

2.5.1 Implementation

Implementation of multidisciplinary learning is done based on topic relationships, educational networks such as school districts, and student interest/understanding. To mention just a few examples of successful multidisciplinary learning, a civil engineering/ biology team's biotechnology class at UNC-Charlotte provided a solid example of multidisciplinary learning to include engineering in technology. In the experience, not only multiple disciplines, but also inter-university collaborations, were successful in providing the students with increased learning experiences and keeping the students interested (Hilger, et al., 2007). K-12 schools can use a similar approach to combine existing strengths within schools such as math and science courses and collaborate to create similar success in technology and engineering.

The multidisciplinary approach between engineering and technology can also involve ethics and politics as an overlap in discussions adding depth and inclusiveness based on student interest and understanding (Braun , et all, 2007). For example, with a discussion of the internet, a discussion of copyright laws could be included or a discussion of energy resources could include the varying political opinions about conservation.

In addition, simply highlighting applications and creativity in engineering and technology with simple mechanical knowledge adds multidisciplinary advantages (Thom, 2001). One example used in classrooms was a discussion of current technological advances.

2.6 Use of Survey in Educational Assessment

Since Fennema and Sherman in the 1970s, surveys have been a standard tool for student attitude assessment (Pierce, Stacey, Barkatsas. 2007). Surveys are most often filled out by the student in the classroom environment. This self-reporting can result in questionable validity, but Kuh indicated five conditions for validity: (i) when respondents know the information requested, (ii) questions are clearly and unambiguously worded, (iii) questions refer to recent activities, (iv) respondents take questions seriously, (v) questions are not perceived to be threatening or to violate privacy (Kuh, 2000). Thus, these conditions have become standards within the surveys for student attitude assessment.

Another issue of concern in survey research is the degree to which those who respond to a survey are significantly different in attitudes or experience from those who did not respond. This issue cannot always be fully addressed, because students and parents need to give informed consent for the student to participate.

Additionally, there has been discussion of the need to avoid negatively worded questions, because (i) it reduces the chances for quick accurate completion of survey (ii) when students see the survey many times it could “seed negative thinking” (Pierce, 2007). In the same vein, if the purpose of the survey is to discover attitude, it should not influence towards positive thinking. In all cases, care should be taken to ensure that wording is non-influencing and clear to allow the survey to be completed in an appropriate amount of time.

Even with these issues, it is essential to research the conceptions or misconceptions held by students, relating to perceptions about technology, pertaining to gender, and pertaining to curriculum change/integration (Lewis, 1999). Moreover the surveys included in the section about student perception of engineering and technology stand as great examples to glean survey techniques, wording, and formats.

Clear examples of negative wording were given in engineering and a technology scale (Hirsch et al, 2007; Jeffery, 1993; Bame and Dugger, 1993). Some of the negatively worded statements include:

- ‘It makes me nervous to have to take math or science classes.’
- ‘I would rather not have technology classes in school.’

Formatting clarity for middle school students is exemplified by Hirsch and Jeffery along with Franton. Using Likert or modified Likert scales with spacing and/or a grid makes surveys easier to follow (Hirsch et al, 2007; Jeffery, 1993; Franton et al, 2002).

2.6.1 Effect Size Analysis

Standardized mean difference effect size analysis is a statistical tool used in social sciences to find practical differences between comparison groups. The magnitude of the effect size indicates the degree difference between the comparison groups (Cohen, 1988). This is discussed with more detail in section 3.7.2.

Depending on the data used, the information available from a standardized mean difference effect size analysis can range from slightly qualitative to largely quantitative. For example with a normally distributed population, an effect size of one showed that individuals in the comparison group had a mean response equal to or greater than the comparison group 84% of the time (Shumway, 1999).

The assignment of the degree of practical significance to different effect sizes can at times be considered completely arbitrary and of little, if any, quantitative significance. There have been several arguments including those stating that all conventions are arbitrary. When establishing the convention for an effect size analysis, a power analysis can be used to ensure that the right convection and sample size, was chosen (Cohen, 1988). In addition, careful investigation of the comparisons can identify small quantitative effects with large practical significance such as shifting opinions.

2.7 Qualitative Inquiry in Educational Assessment

While much can be gained from quantitative Likert-scale surveys, additional insights are found through qualitative inquiry. Hoepfl states the differences of qualitative and quantitative inquiry as, “Where quantitative researchers seek causal determination, prediction, and generalization of findings, qualitative researchers seek instead illumination, understanding, and extrapolation to similar situations” (Hoepfl, 1997).

Historically, especially in engineering and technology, the value of this and other qualitative research was overlooked. However, the acceptance of qualitative research has become evident in recent years through choices in education to incorporate:

1. qualitative methods courses
2. qualitative research textbooks
3. faculty who specialize in qualitative research (Eisner and Peshkin, 1990).

With acceptance of qualitative methodological analysis in education, engineering and technology experts are also beginning to accept qualitative research approaches especially as the analysis is becoming more systematic. One way to analyze comments is the Spradley Analysis. This analysis includes three main levels of analysis as previously detailed in the method of data analysis discussed in Section 3.7.3. To add to this analysis a study of the absences (such as a connection between the class experience and the working world) from teacher and student responses provides further insight. The validity of the data from the qualitative and quantitative research can confirm research findings and add strength and confidence in the results.

3 Discussion of Research Method

3.1 Development of Instrument

The *Technology and Engineering Attitude Scale (TEAS)* survey instrument was developed in three stages: (i) selection of measurement criteria, (ii) construction of statements, and (iii) formatting. Each step included a detailed review of literature and consideration of suitability for use with the selected students.

3.2 Selection of Measurement Criteria

The Technology Attitude Scale and Pupils Attitude Toward Technology-USA measurement criteria were investigated and those of interest were selected and combined with additional criteria (Jeffery, 1993; Bame and Dugger, 1989). The result was eight measurement criteria defining the scope of areas which students' attitude towards and perception of technology and engineering would be investigated. The selected criteria were:

1. Learning Interest
2. Career Interest
3. Importance of Contribution to Society
4. Multidisciplinary Relationships
5. Gender

6. Problem Solving Connection
7. Problem Solving Confidence
8. Engineering and Technology Difficulty Level

3.3 Construction of Survey Statements

After determining the measurement criteria, the next step was to construct the survey statements and thus the desired survey response options. The standardized analysis available for Likert-scale type statements appealed to the purposes of this instrument. The Likert-scale for this instrument was modified to a six point scale. The points were assigned zero through five. With 0 corresponding to “I don’t know” and 1-5 corresponding to a typical 5-item Likert Scale with 1 corresponding to strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree.

Examples from current engineering and technology surveys (Hirsch et al, 2007; Jeffery, 1993; Bame and Dugger, 1989), and adapted statements from these surveys non-similar criteria (i.e., problem solving) were developed. These drafted statements were presented to a panel of experts including Dr. Steven Shumway, Dr. Ronald Terry, Professors of Technology and Engineering Education, and Dr. Linda Hirsch, Evaluator for New Jersey Institute of Technology Center for Pre-College Programs. (This panel included over 50 years of combined teaching experience in engineering and technology at middle school through college levels.)

The survey statement iterations included adaptations to ensure it met the understanding level for a middle school aged students. One example of this iteration was:

Draft 1: The world would be a worse place without engineering and technology.

Draft 2: Engineers make the world a better place.

Final Draft: Engineers and technologists help make people's lives better.

In addition to constructing the statements, the number of statements was restricted for usability. The bounds were set for the entire survey to generally take less than 20 minutes to complete.

As well as consideration of time, care was taken when varying the phrasing (negative/positive) of the statements to ensure clarity as negative phrasing is often confusing. This evaluation included comparisons to established and successful surveys as validation for the clarity of negatively worded statements as well as consultation with the panel of experts (Hirsch et al, 2007; Jeffery, 1993).

The following sections provide the survey statements grouped by measurement criteria. The criteria are discussed in hierarchy based on the number of statements associated with the criteria.

3.3.1 Learning Interest

The measurement criterion directly connected to the student's current learning interest in Engineering and Technology had the most statements. These statements involved topics of technology and engineering including clubs, classes, nervousness towards, confidence in advanced classes, as well as direct interest. The statements were:

- If there was a technology and engineering club at my school, I would like to join.
- I am not interested in technology and engineering.
- I would like to learn more about technology and engineering at school.
- I think there should be a class at my school related to technology and engineering.
- I would be nervous to take a technology and engineering class.

- I think I could do well in an advanced technology and engineering education class.

3.3.2 Career Interest

Another criterion focused on and measured the degree of interest in engineering or technology careers. The five statements for this criterion included topics on attitude and future career vision. The statements were:

- Working in engineering and technology as a job would be boring and dull.
- I think that having a job in engineering or technology would be fun.
- I would like a job that lets me do a lot of engineering and technology.
- I would like to be an engineer when I grow up.
- I would like to be a technologist when I grow up.

3.3.3 Importance of Contribution to Society

There were five statements to measure the extent that engineering and technology is important to society. It also evaluated the student's perception of contributions made by engineering and technology to society as good or bad. In addition to general statements of good versus bad, specific societal issues were addressed. The statements were:

- Technology and engineering has brought about more bad things than good things.
- Engineering and technology make our lives more comfortable.
- Societal issues, like water and air pollution, influence the jobs of technologists and engineers.
- Engineers and technologists help make people's lives better.
- Engineering and technology have nothing to do with our lives.

3.3.4 Multidisciplinary Relationships

The third measurement criterion was chosen to help investigate multidisciplinary relationships, specifically the students' connection between math, science, engineering, and technology. This criterion also had five statements. These statements were:

- To me, the field of science is related to the field of technology and engineering.
- I think engineering and technology are often used in science.
- Science has nothing in common with technology and engineering.
- In engineering and technology, you use math.
- Engineers and technologist use a lot of math and science.

3.3.5 Gender Equality

Role pattern was measured through four statements which focused specifically on the extent the students felt females and males are suited for engineering and technology. While answer differentiation in other categories gave insight to gender differences, attitude about gender was directly investigated with these statements:

- Boys know more about engineering and technology than girls.
- A girl can have a technical job.
- Boys are better at being engineers than girls.
- Girls can be as successful doing engineering and technology as boys.

3.3.6 Problem Solving Connection

Along with measuring the students' connection between math, science, engineering, and technology, their connection between problem solving, engineering, and technology was investigated. As a specific measurement criterion, the following three statements were included in the survey:

- When I think of engineering and technology, I mostly think of solving problems.

- Engineers and technologist solve problems.
- You do not have to problem solve to be an engineer or technologist.

3.3.7 Problem Solving Difficulty

With verification of the student's perception of problem solving in relationship to engineering and technology, another subscale was used to look at the extent to which the student felt capable of solving problems. Three statements were included as follows:

- In my everyday life, I am able to solve problems well.
- I am good at problems that can be solved in many different ways.
- Solving problems is hard

3.3.8 Engineering and Technology Difficulty

The final criterion focused on the students' perception of the difficultly of engineering and technology. As with confidence in problem solving capability, this subscale gave insight into the correlation between the level of interest and the level of confidence in the discipline. These statements were:

- You don't have to be smart to study engineering and technology.
- To be good at engineering or technology you have to be very smart.
- To become an engineer or technologist, you have to take hard classes.

3.4 Formatting of Instrument

Successful surveys were also used as models for the formatting of this instrument (Hirsch et al, 2007; Jeffery, 1993; Franton et al, 2002; Pierce et al, 2007). Through these examples and personal collaboration with Dr. Linda Hirsch the survey was formatted as shown in the following figure.

		I don't know	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I am not interested in technology and engineering.	0	1	2	3	4	5
2	Boys are better at being engineers than girls.	0	1	2	3	4	5
3	Engineering and technology have nothing to do with our lives.	0	1	2	3	4	5
4	To be good at engineering or technology you have to be very smart.	0	1	2	3	4	5

Figure 3-1: Example of Survey Format

The statement order was determined through a random number generator. This reduced the chance that students would recognize the eight measurement criteria and provide answers based on perceived researcher or teacher expectation to rather than personal perceptions and attitudes.

The final version of the survey (Appendix A) was four pages including a cover page with date and gender as the only identifying information. The cover page also included instructions emphasizing the purpose of the study was to investigate student perception and attitude. Just as the criteria statements, the instructions were adapted from examples (Hirsch, 2007) and reviewed for age level appropriateness and clarity.

3.5 Implementation of Survey

3.5.1 Participants

Participants included 7th grade students and teachers in the Salt Lake, Utah, and Wasatch counties enrolled in or teaching the course: *Introduction to Career and Technical Education*. The participants were evaluated during the Technology Education rotation which made up one block of the overall three block course**.** There were a total of four teachers at four different schools in three school districts and nearly 200 students.

3.5.2 Confidentiality

Data from the surveys, observations, interview transcriptions and analysis did not include information that could be used to identify the participants (name, address, or any other identifying information other than class and gender). In addition, the raw survey data and all other data with identifying information was not made available to anyone other than co-investigators and was kept within the Principal Investigator's (PI) locked office through project completion.

3.5.3 Informed Consent

Consent for the research was received according to the specific internal review boards' protocols of each public school. These included approval from district research coordinators, school principals, and classroom teachers conducted through electronic and phone correspondence.

An informed consent form was created to ensure parents and students had accurate information about the students' participation and their rights. It included details of the purpose of the study, potential risk of the educational survey, individual student's rights, and contact information to learn more about the study. The form (included in Appendix C) was reviewed and approved by the Brigham Young University Internal Review Board as well as the school districts and principals.

The form was given to the students to take home and review with their parents or guardians. The teacher collected the forms from the students during class. All subsequent interactions were based upon the confirmed informed consent.

3.5.4 Administration of Instrument

As consent allowed, the Technology and Engineering Attitude Scale was given to the students within the first two weeks of the technology rotation of the course Introduction to Career and Technical Education by the teacher. Students were given the survey again within the last two weeks of the class.

3.6 Class Visits

The principal investigator visited some of the classes. No quantitative analysis of the survey was done before the class visits in order to help ensure that the investigator did not come to classes with preconceived notions of the student experience. These visits were completed during an average day. The principal investigator was introduced to the class in connection with the surveys that had been taken. Upon introduction, the class preceded as normal as possible. To allow for the most normal behavior of the students, the investigator sat to the side for the first few minutes of class and allowed the students to begin their work. During this time, the investigator made observations about the class environment and student interactions. Those observations included décor of the classroom, teacher/student interaction, and level of student engagement in work.

Once the students were working individually or in groups on projects, the investigator walked around the classroom/lab making further observations and talking with the students about their experiences and perceptions of technology and engineering. The inquiry included informal dialogue and questions to explain what they are working on and their attitude. Typical inquiry with a student included:

- What are you making?
- Have you done it before?
- How do you feel about this class?
- What is your favorite part of this class so far?
- Do you know what you want to do when you grow up?
- Do you know what kind of engineer?
- Do you know what chemical engineers do?
- Do you want to do stuff like this again?

Triangulating questions were asked to validate the qualitative inquiry. For example, negative case analysis was used by asking the same student questions in different ways to increase understanding of student responses (i.e. after answering how they felt about the class; the students were asked why they felt that way.)

3.7 Data Analysis

3.7.1 Instrument Validity and Reliability

Several measures were used to confirm face validity and reliability. By comparing survey responses with class visits showed of triangulation of the data was done. Because the survey responses were consistent with classroom observations and interviews it seems the data is reliable.

3.7.2 Likert Scale Responses

An effect size analysis of Likert scale responses was used, because a lack of random sampling restricts the use of standard statistical tests. The effect size analysis is a standardized mean difference statistical tool. The magnitude of the effect size indicates the degree of difference between the comparison groups (Cohen, 1988) and was calculated according to the following equation:

$$Effect\_Size = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{\sigma_1^{\ 2} \cdot (n_1 - 1) + \sigma_2^{\ 2} \cdot (n_2 - 1)}{n_1 + n_2 - 2}}} \quad \textbf{(3-1)}$$

Where x was the average responses, σ^2 are variances and n are number of survey responses.

The next table (3.1) explains the meaning for the magnitude of the effect size means. It shows that having an effect size of 0.3 indicated the average response from comparison group one was greater than or equal to 62% of the responses in comparison group two. As another example, an effect size of 1.6 indicates that the average response from comparison group one was greater than or equal to 94.5% of the responses in comparison group two.

Table 3-1: Effect Size Magnitude Explanation

Cohen's Standard	Effect Size	Percentile
	2	97.7
	1.8	96.4
	1.6	94.5
	1.4	91.9
	1.2	88
	1	84
LARGE	0.8	79
	0.7	76
	0.6	73
MEDIUM	0.5	69
	0.4	66
SMALL	0.3	62
	0.2	58
	0.1	54
	0	50

The comparisons categories which included performance of an effect size analysis included:

- Class to class
- Female students to male students
- Students with female teacher to students with male teacher
- Female students with female teacher to male students with male teacher
- Female students with male teacher to male students with female teacher

3.7.3 Class Visits

Class visit observations and dialogues were recorded and transcribed. Transcriptions were analyzed together for patterns and themes according to the eight criteria of investigation. In addition, other emerging themes were studied according to a simplified version of the Spradley Analysis.

This analysis included two main levels of evaluations. First, investigators looked for domains, i.e. different categories of responses that seem to influence students' concept of and attitude towards engineering and technology. The domains to be considered in this study were the eight measurement criteria and any additional categories that arose during analysis (i.e. décor of classroom). The second step was a taxonomy analysis. Where collected data points and domains were analyzed for relationships and ranked based on level of practical significance. This included how often the student said something and how the qualitative data compared with survey results.

In addition, detailed anecdotal description and quotes without connection to identifying information were included in the analysis of the research to increase reader transferability without generalization.

4 Data and Results

The purpose of this study was to investigate middle school student perception and attitude toward technology and engineering and to better understand how the gender of the teacher, gender of the student, and information provided in technology classes affected their perception and attitude. The study used eight measurement criteria to investigate the research questions. For each of the eight criteria, multiple comparisons of instrument results, open ended interview questions, and observations were utilized to investigate affects. The study included 200 seventh grade students taking the Introduction to Career and Technical Education course at four different schools in Utah.

The data and results section will first provide an overview of the class visits explained, which provides insight into the students' class experiences and allows a deeper understanding of the results discussion. Following the class visit overview, the final version of the survey statements is outlined and summarized. Finally trends resulting from the survey, observations, and interviews will be discussed. The groups listed below are used to organize the trends:

- All Students
- Class
- Gender of teacher

- Gender of student
- Gender of student and teacher

There were several key results from the data analysis, students were interested in engineering and technology during class and students with a female teacher agreed more strongly that both males and females were fit for engineering and technology.

4.1 Class Visits

In order to understand how technology classes affected students' attitudes and conception, a rich description of the classroom environment was required. Two of the four classrooms were visited. The classroom atmosphere and activities, and a dialogue record of the principal investigator's (PI) interview with students are included.

4.1.1 Male Teacher's Classroom

The students with a male teacher were building a model airplane. Their tasks were to punch out the pre-made pieces, assemble them, and decorate the airplane. The teacher had provided video demonstration of how to build the plane. In addition to the video, each student had a step by step written procedure. Once working on their task, the teacher would point out things done correctly to help the students get a clearer idea of what they should be working on.

Each student created their own airplane and the majority of them were able to follow the instructions independent from the teacher. The specific instructions included folding the cardstock plane pattern, lining up holes, and gluing parts together. The most unique strategy was displayed by Eden who sat on the pieces while the glue dried, so that she could continue with the other steps in building her plane (discussed in 4.1.3).

Figure 4-1 is a schematic layout of the male teacher's classroom. Although independently working, the students sat at tables with six to ten other students. The seating was self-directed resulting in segregated tables of only boys or only girls. The walls of the classroom had pictures of airplanes, carpentry made by students, and cabinets for students to store their current projects. The television on which they watched the instructional video was sufficiently large and reasonably current technology.

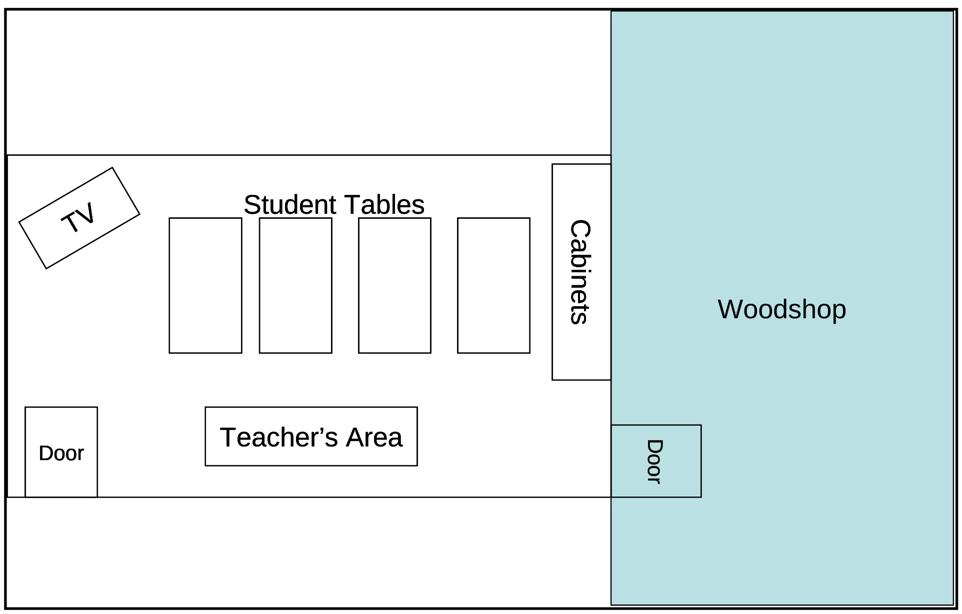

Figure 4-1: Arrangement of Male Teacher's Classroom

4.1.1.a Interview Dialogue Data – Female Student Perception with Male Teacher

The representative dialogue between the principal investigator and a female student in the class to present the female students' perception and attitude during class is provided below:

Scarlet: I love this class. You should have seen our car. It broke into a thousand pieces, but our egg survived.

Principal Investigator (PI): On that track, right here?

Scarlet: Yeah, on the fourth level.

PI: What else have you done?

Scarlet: We did this paper thing where you have to make a tower and see how strong it was. You have to put like bricks on it and he gave us ideas.

PI: You built something from paper?

Scarlet: Yeah, you had to like stick it up. I hated that

PI: How is your airplane coming along?

Scarlet: Oh my gosh, oh my gosh, I did it. Except it came apart.

PI: What are you missing?

Scarlet: I found it. It was connected to hers.

PI: From when they were punched out?

Scarlet: Yeah.

PI: What is your favorite part of this class?

Scarlet: We get to build things. I like cool projects and no notes. Notes are too boring

PI: How do you learn in this class?

Scarlet: Hands on! And I like it when we get to have partners.

PI: Do you know what you want to be when you grow-up?

Scarlet: Umm, I don't know. I sort of want to be famous.

PI: What are you good at that you can be famous about?

Scarlet: Acting. Teacher, I don't know what to do now.

PI: You are doing so good. What number are you on (in the instructions)?

Scarlet: Using a pencil and a ruler draw a faint line contact between, no contact the two pin holes from the horizontal stabilizer. I don't know what that means? Glue eight onto the top of the fusel lodge, angling the center line. I cannot do this.

PI: Do you see pin holes anywhere?

Scarlet: Ahh, I always do it backwards

Teacher to class: You will have all next class period to decorate and finish your aircraft and we still haven't decided when to grade them.

Scarlet: I am not done. Do I go like this Teacher, I need your help. I don't know. She just told me that this is the angle.

4.1.1.b Interview Dialogue Data – Male Student Perception with Male Teacher

The dialogue between the principal investigator and male students in the class is provided below to represent the male students' perception and attitude:

PI: What do you think about this class?

Trevor: Umm, it is pretty fun. You have got to pay attention. It is better than doing paper work.

PI: What is fun about this class?

Trevor: I love building things.

PI: Have you built anything other than this airplane?

Trevor: A crash test dummy. I didn't like it.

PI: How did your crash test dummy do?

Trevor: The car died on level one and the egg survived. Then on level four the car did not explode, but the egg died.

PI: So you could put the car back together after each level?

Trevor: Yeah, you had four minutes to do repairs.

PI: Did you do it all by yourself?

Trevor: No, we had partners.

PI: There was no competition?

Trevor: Ahhh, no, just to get a grade you had to get 5 levels (to get a good grade).

PI: Are you figuring out how to make your plane?

Trevor: Nod, Yeah. I wasn't here when we learned how to do the first part, but I am doing it.

PI: That is cool. Do you know what you want to be when you grow-up?

Trevor: I want to be an engineer or a surgeon? I don't really know.

PI: What kind of engineer?

Trevor: A good one.

PI: What kind of stuff do you like to do?

Trevor: Build

PI: So maybe like a mechanical or manufacturing or civil engineer? You also mentioned you might want to be a surgeon. Why is that?

Trevor: Yeah, they are rich and they have like everything you could like possibly want.

PI: Do they have time to play?

Trevor: Well, I don't know. They have like horses and a swimming pool.

4.1.2 Female Teacher's Classroom

The students with a female teacher were having a laboratory day. They were instructed to fill out a form with the work plans for the day, leave them on their desk and go to work. The students followed her instructions and worked on a variety of different projects including bridge building out of wood or on the computer, making cards, planning the layout of a house, testing monorails, and making videos. While the students worked, the teacher walked around. In general, the students did not need help and were making good progress. Most of the students were working in groups on one project or working next to someone that was working on a similar project. The groups were self directed and based on working with people who wanted to work on a similar project. Most of the groups included both male and female students.

The classroom was set up as shown in Figure 4-2 with the teacher's desk at the front of the room:

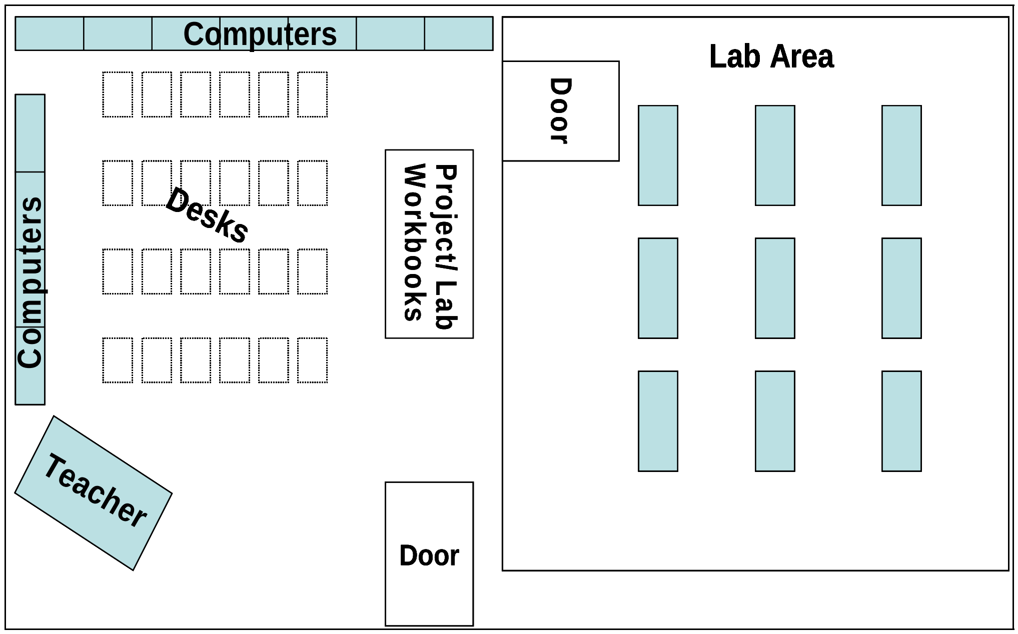

Figure 4-2: Arrangement of Female Teacher's Classroom

There were pictures of engineers, technologists, and current technology news on the walls. The students wandered throughout the computer, desk, and laboratory areas to work on their projects. There was a small television mounted on the wall and the computers had a variety of office and engineering software.

4.1.2.a Interview Dialogue Data – Female Student Perception with Female Teacher

The dialogue between the principal investigator and representative female student in the class is provided below as insight into female students' perception and attitude:

PI: Are you designing a home?

Kira: Yeah

PI: Does it help you in any of your other classes?

Kira: Some of it is just fun.

PI: This seems kind of like being an interior designer.

Kira: Yeah

PI: Or maybe even an architect.

Kira: Yeah, I have thought about being an architect.

PI: That is awesome.

PI: What is your favorite thing that you have done in this class?

Kira: Umm…probably my favorite thing was doing the hands on stuff. But my favorite thing to make was the shirt and I liked the um the G.P.S. thing.

PI: What was that?

Kira: We were all in groups and our teacher gave us all a G.P.S. And she had golf tees all over the school and we had to plug in coordinates to our G.P.S. and we had to go find it. And the first team to find it got a treat. Ahh, and we made a car.

PI: Oh the rubber band car, did that work pretty good?

Kira: Yeah

PI: Did you like or nah?

Kira: It was fun to make using the band saw.

PI: It was fun?

Kira: Uh Huh,

PI: Good

Kira: Yeah, but I was scared of the machines.

PI: Do you think you will take other classes like this.

Kira: (Shake head no)

PI: No?

Kira: No, my eyes will start to hurt.

PI: Too much at the computer?

PI: Is the class pretty hard or nah?

Kira: Nah, it is easy. Computer design is pretty hard sometimes.

PI: Does that make it seem more fun?

Kira: I like classes that are easy more than classes that are hard.

PI: What is your favorite class?

Kira: This one.

PI: Why?

Kira: We get to do hands on stuff.

PI: Do you know what you want to do when you grow up?

Kira: Umm, I don't know. My dad's a pilot and …. (Murmurings that PI cannot understand for a few seconds). A lot of people in my family are teachers. Like my uncle and my aunt, they are dance teachers. And my mom, she was a dance teacher for 15 years and now a 5th grade teacher. And my grandma on my dad's side is a kindergarten teacher.

PI: Ah huh

Kira: So, I might want to be a teacher

PI: Do would you want to teach elementary school?

Kira: Nah, probably history.

4.1.2.b Interview Dialogue Data – Male Student Perception with Female Teacher

The dialogue between the principal investigator and a representative male student given below to represent the male students' perception and attitude:

PI: What are you making?

Martin: This little electrical car thing

PI: Have you done it before?

Martin: No,

PI: It looks complicated

Martin: Yeah, especially when you can't find the right part

PI: Do you like this class?

Martin: Yeah it's my favorite out of probably all my classes

PI: Out of all you have ever taken, or just this year?

Martin: Just this year I don't know PE might be my favorite

PI: Do you know what you want to do when you grow

Martin: Yeah kinda, an Engineer.

PI: Do you know what kind of engineer

Martin: Ah not yet

PI: Do you know what chemical engineers do?

Martin: Ahh, kind of

PI: So, As a Chemical Engineer, you can do lots of things, work for energy companies, or you can work on environment stuff, you can work at chemical companies, or cosmetic companies?

Martin: Yeah

PI: So do you want to do stuff like that or more mechanical

Martin: I think more like buildings and stuff more like civil. I also kind of like chemistry.

PI: Yeah, Do you guys take a Chemistry class?

Martin: Um in our science class, we are going to spend maybe a week in it, I wish it was more though.

PI: Will you get to take chemistry in high school?

Martin: Yeah I think so

PI: Do you use anything you learn in this class for other classes?

Martin: Umm yeah.

PI: What class?

Martin: This other class with the computers and stuff, how to use the spread sheets

PI: Do you use it in like your Math or science classes?

Martin: I have used it to do like um like um kind of like a scores sheet to write down scores and stuff.

PI: Did that work good?

Martin: Yeah

PI: Do you think that engineering and technology are good for society or not really?

Martin: Well probably they are probably good in ways and bad in ways and they are going to get pretty far It depends on what kind.

PI: What do they do that is good?

Martin: Work in environmental engineering is good

PI: What bad kind of engineering is bad?

Martin: Engineering that effects environment in a bad way.

PI: Did you learn anything about technology in the news or current events?

Martin: Cars that run out of compressed air and Flying cars.

PI: I haven’t heard about that

Martin: It is like a personal helicopter jet sorta of thing they are making a whole lot of kinds. It is pretty cool

PI: So do you guys look up stuff at home or did you learn about it in this class?

Martin: This class

PI: So did you do the bridge project in this class?

Martin: I didn’t ever have time. I am going to try to do it.

4.1.3 Anecdotal Observations of Individual Students

While the observations of individual students are not necessarily representative or transferable, the observations show the diversity of the student experiences, perspectives, and influences. These anecdotes were included to provide a perspective on the individuality of students and the importance of recognizing each person’s unique perspective.

A male student, Terron, with a male teacher described his career interest to be highly dependent on the proposition to be rich.

A male student, Clark, with a female teacher exemplified the significance an individual can have in directing a child’s career interest. During his career interest response, he described his father’s suggestion to be an engineer in the military in detail. Clark showed genuine interest in pursuing this suggestion by describing the building design (or perhaps structural building) and problem solving he does at home. During this discussion, he was working alone building an airplane after a picture he had found on the internet. Later when talking with Clark’s teacher, she attested to his high involvement in class and that his interest in engineering was highly influenced by his father’s suggestion.

After the male teacher described one of the steps of making the airplane to include holding two pieces together for a few minutes to allow the glue to dry, a female student, Eden, showed creative problem solving. Eden glued her two pieces, placed a piece of wood on top of them, and then sat on it while she worked on the next step. All of the other students got to that point, held the pieces together, and stopped making further progress until they were dried.

A female student, Anna, was quietly uninvolved in the technology and engineering curriculum. Within the first few minutes of class, Anna totally disengaged herself by reading a fantasy book. During our discussions, she explained her interest and involvement with English and dance. She could not describe any interest in engineering or technology. In a later conversation with her teacher, it was clear that this behavior was typical of Anna.

4.2 Survey Instrument

The *Technology and Engineering Attitude Scale (TEAS)* survey instrument in the format provided to the students (Appendix A) allowed responses to 34 criterion statements. The summary statements are provided in Table 4-1 to allow discussion of the results related to these criterions. The statement numbers correspond to the results shown in Tables 4-2 through 4-18, which discuss the responses of students with pre and post survey results. The statement numbers will be used to group the responses by topics.

Table 4-1: Survey statements summary

S #	Criteria Statement
1	I am not interested in technology and engineering.
2	Boys are better at being engineers than girls.
3	Engineering and technology have 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 are often used in science.
7	Engineers and technologists 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 and technologist 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 do not 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 able to solve problems well.
23	I would like to be an engineer when I grow up.
24	Societal issues, like water and air pollution, influence the jobs of technologists 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 make 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.

4.3 Trends from Survey and Class Visit Data

The survey data, open ended interview questions and observations were combined in the results analysis to determine the prevailing trends. In the results sections, the analysis of the survey measurement criteria data are grouped by topics to show the differences in comparison groups such as Pre (two weeks at the start of class) and Post (two weeks before the end of class) or male and females students' surveys. The differences are shown by the mean response, effect size, opinion (agree/neutral/disagree/shifting – change between comparison groups), and direction of change (in intensity towards extreme or neutral opinions). The percentages presented by Cohen as discussed in section 3.7.2 are included for a perspective on the significance of the effect sizes. Note that in some cases these percentages are estimates as the restriction to a normally distributed population was not confirmed.

The data analysis is provided in table format at the beginning of each discussion section. After the table a general discussion and triangulation of key findings and qualitative data are grouped by the eight measurement criteria provided. The results discussion is ordered as follows:

1. Mention of measurement criteria that showed no practically significant effect sizes.
2. Discussion of measurement criteria with practical significant effect sizes starting with the criteria with the maximum practical significance.
3. Additional insights provided when evident.

For the students overall, by gender of student, and by gender of teacher, the attitudes of the students are also discussed in general even when there are not practically significant effect sizes. This is done for each measurement criteria. The discussion is included to allow the general perceptions of the students to be understood even when there were not changes in perception.

4.3.1 Overall Criteria Relationships and Comparison

The survey instrument data was analyzed to determine the Pre and Post comparison using all the data from the four classrooms. This allowed a general trend to be developed without bias for classroom environment, gender of student or teacher.

Table 4-2: All students pre to post comparison

S #[1]	Pre Mean[2]	Post Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.50	2.43	0.06	Disagree	Extreme	*
12	3.09	3.16	0.07	Agree	Extreme	
14	3.80	3.80	0.00	Agree	No Δ	
15	2.48	2.53	0.04	Disagree	Neutral	*
19	3.48	3.26	0.20	Agree	Neutral	
20	2.73	2.59	0.11	Disagree	Extreme	
Interest in career						
10	2.79	2.71	0.07	Disagree	Extreme	
13	3.53	3.37	0.15	Agree	Neutral	
17	2.30	2.33	0.03	Disagree	Neutral	
23	2.43	2.42	0.01	Disagree	Extreme	
28	2.42	2.39	0.03	Disagree	Extreme	*
Importance and contribution to society						
3	1.47	1.48	0.01	Disagree	Neutral	*
7	4.04	4.22	0.22	Agree	Extreme	
24	3.71	3.76	0.05	Agree	Extreme	
26	2.16	2.20	0.05	Disagree	Neutral	*
29	3.91	3.95	0.04	Agree	Extreme	
Difficulty						
4	3.11	3.07	0.04	Agree	Neutral	
31	3.12	3.07	0.05	Agree	Neutral	*
33	2.62	2.61	0.01	Disagree	Extreme	*
Relationship to Math and Science						
6	3.93	3.98	0.05	Agree	Extreme	
11	4.17	4.05	0.15	Agree	Neutral	
16	1.67	1.69	0.03	Disagree	Neutral	*
27	3.79	3.82	0.04	Agree	Extreme	
34	4.07	4.16	0.11	Agree	Extreme	
Gender						
2	1.76	1.60	0.16	Disagree	Extreme	*
8	4.53	4.53	0.00	Agree	No Δ	
21	4.65	4.61	0.05	Agree	Neutral	
32	1.76	1.81	0.05	Disagree	Neutral	*
Connection to Problem Solving						
5	4.02	4.07	0.06	Agree	Extreme	
18	1.8	1.93	0.14	Disagree	Neutral	*
30	2.9	2.97	0.07	Disagree	Neutral	
Problem Solving Capability						
9	3.36	3.34	0.02	Agree	Neutral	
22	3.68	3.76	0.09	Agree	Extreme	
25	2.72	2.66	0.06	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

As shown, when comparing the responses from all students Pre (during the first two weeks of class) to Post (during the last two weeks), there were no practically significant effect sizes in any of the eight measurement criteria.

Importance of Contribution to Society: The survey statement with largest magnitude effect size (0.22) was related to the importance and contribution that engineering and technology have on society. An effect size of 0.22 means that students post test mean scores on this item were equal to or higher than 58% of their pretest scores. This result suggests that students' perceptions of the importance of contribution that engineering has to our society had a positive shift from pre to post scores and that this shift had at least small values of practical significance. During the class visits, it was clear that most students understood that engineers and technologist provided items for their enjoyment as video games, bridges, and media players. When asked if engineers and technologist were good or bad for society, typical comments stated "Well probably they are good in ways and bad in ways." The even smaller magnitude of the other effect sizes within the importance and contribution to society criteria do not allow for confirmation of this change, but the fact that the students both Pre and Post generally agree with positive statements about importance and contribution and generally disagree with negative statements showed their overall perception is consistent and answers the research question that students do see connections between engineering, technology, and society. For instances, statement 3 shows that the students in both pre and post responses strongly disagreed (1.47 and 1.48) that 'Engineering and technology have nothing to do with our lives.'

Interest in Learning: The students responded that they are interest in learning about engineering and technology pre and post. This is promising as it means that the learning process did not interfere with the student preconceived interest. The only learning interest exception is statement 21, which likely portrays a lack of interest in clubs in general rather than engineering and technology. This could be due to other barriers associated with a club that were separate from an interest in learning (i.e. requirements for coming before or after school which could be prohibited by other activities or abilities to have transportation). A technology club was available with open time for students to come after school to work on projects. This particular club may have been what the students were associating with this question with rather than an overall interest in clubs.

Interest in Career: Statements 10, 17, and 23 show that the students overall are slightly to the not interest side of neutral about having a career in engineering and technology. But statements 13 and 28 make it apparent that this is not, because the job would be dull or boring…it would be fun from the students' perspectives.

Difficulty: The students thought that one does have to be smart maybe even very smart and has to take hard classes to be an engineer and technologist. The perception was only slightly different from neutral though.

Relationship to Math and Science: Overall the students perceive that engineering and technology are connected to math and science. The similarity of the strength of perceived connection suggests that math and science seem equally related to engineering and technology—only slight if any neutrality shown.

Gender: The students are between strongly agree and agree for all statements indicated that the students definitely feel that both boys and girls are fit for engineering and technology. This is definitely the attitude that can help overcome the gender gap with engineering and technology.

Connection to Problem Solving: Statements 5 and 18 suggest an agreement that problem solving is connected to engineering and technology. Statement 30 clarifies that the students to not necessarily agree that ‘When they think of engineering and technology, they mostly think of solving problems.’ Note that statement 30 responses could likely be considered neutral as the means were 2.90 and 2.97, where 3.00 is neutral.

Problem Solving Capability: The students perceive that they are capable of solving problems.

Additional Insights: Another research question was answered with data from Table 4-2 by the consistent response. These responses showed that the developed survey instrument gave insight into students’ perception and attitude towards engineering and technology. The confirmation of consistent answers to survey statements (agree with positive and disagree with negative or alternatively agree with negative and disagree with positive) was observed each time the survey was taken. To clarify, even when the perception changes between Pre and Post, the overall perception during Pre within each criterion is consistent and the overall perception during the Post within each criterion is consistent. Most often the effect sizes are of similar magnitude. In addition, the similarity between survey response and class visit qualitative data confirms that the survey instrument provides insight into perception and attitude.

4.3.2 Class Trends

Further evaluations were completed by an in depth analysis of data grouped by class. This analysis can be seen in Tables 4-3 to 4-7. Data summarized in the tables by Classroom 1, 2, 3, and 4 combines survey data from multiple class periods taught by the same teacher. Thus each class data set represents data from up to six individual class periods. The discussions after the tables emphasize the pre to post changes in the student perception and attitude based on the survey responses. An account of qualitative analysis is given to companion the survey responses where available.

This section is included to allow for insight into variations that may not have been apparent from the overall comparisons. For example, the change in perception and attitude of students in class 2 was greater than the other three classes. Thus, this section gives further information about the influence of students' classroom experience.

Table 4-3: Pre to post test comparison for students in Class 1

S #[1]	Pre Mean[2]	Post Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.26	2.42	0.12	Disagree	Neutral	*
12	3.07	3.02	0.04	Agree	Neutral	
14	3.76	3.71	0.05	Agree	Neutral	
15	2.1	2.41	0.29	Disagree	Extreme	*
19	3.47	3.36	0.09	Agree	Neutral	
20	2.74	2.65	0.07	Disagree	Extreme	
Interest in career						
10	2.98	2.73	0.21	Disagree	Extreme	
13	3.49	3.44	0.05	Agree	Neutral	
17	2.31	2.31	0.01	Disagree	No Δ	
23	2.38	2.37	0.01	Disagree	Extreme	
28	2.43	2.48	0.05	Disagree	Neutral	*
Importance and contribution to society						
3	1.38	1.53	0.17	Disagree	Neutral	*
7	4.12	4.01	0.14	Agree	Neutral	
24	3.72	3.59	0.13	Agree	Neutral	
26	2.02	2.01	0.01	Disagree	Extreme	*
29	3.92	3.82	0.11	Agree	Neutral	
Difficulty						
4	3.35	3.13	0.20	Agree	Neutral	
31	3.24	3.15	0.10	Agree	Neutral	*
33	2.49	2.62	0.11	Disagree	Neutral	*
Relationship to Math and Science						
6	3.93	3.92	0.01	Agree	Neutral	
11	4.24	4.19	0.07	Agree	Neutral	
16	1.8	1.65	0.16	Disagree	Extreme	*
27	3.72	3.85	0.15	Agree	Extreme	
34	4.36	4.07	0.38	Agree	Neutral	
Gender						
2	1.83	1.63	0.2	Disagree	Extreme	*
8	4.51	4.55	0.05	Agree	Neutral	
21	4.61	4.59	0.02	Agree	Neutral	
32	1.66	1.73	0.06	Disagree	Neutral	*
Connection to Problem Solving						
5	3.91	3.91	0	Agree	No Δ	
18	1.85	1.86	0.01	Disagree	Neutral	*
30	2.69	2.78	0.09	Disagree	Neutral	
Problem Solving Capability						
9	3.67	3.42	0.27	Agree	Neutral	
22	3.95	3.61	0.38	Agree	Neutral	
25	2.79	2.66	0.12	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of “I do not know” were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

Class 1 showed only small effect sizes, meaning there were only two practically significant effects in the eight measurement criteria they were in problem solving confidence and relationship to math and science. The other six measurement criteria showed no significant effect sizes.

Problem Solving Confidence: The largest effect size was in the category of problem solving confidence. The effect size of 0.38 for statement 22 means that students post test mean scores on this item were equal to lower than 65% of the pre survey response confidence in problem solving. The finding resulting from the 9th statement (students do not believe their have significant capability to effectively problem solve) further confirmed this finding.

The perception regarding problem solving confidence was also investigated during class visits. The students could describe situations to overcome difficulties during projects. One student described a group's problem when building the bridge and could explain why the problem occurred and then showed the finished project completed without the problem. This could suggest that the students gained problem solving experience that caused them to have a more realistic perspective about their capabilities.

Relationship to Math and Science: Statement 34, 'In engineering and technology, you use math' also showed a small effect size (0.38, 62%). The responses showed that after having taken the engineering and technology class the students felt less strongly that there was a connection to math. Overall, there was not a clear trend regarding change in perception of the connection to math, but students did agree that there is a connection between engineering and technology to math and science.

Table 4-4: Pre to post test comparison for students in Class 2

S #[1]	Pre Mean[2]	Post Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	3	2.36	N/A	Shifting	N/A	*
12	3.57	3.35	0.23	Agree	Neutral	
14	4.04	4.14	0.15	Agree	Extreme	
15	2.33	2.64	0.28	Disagree	Neutral	*
19	3.74	3.52	0.23	Agree	Neutral	
20	2.96	2.71	0.21	Disagree	Neutral	
Interest in career						
10	2	2.79	N/A	Disagree	N/A	
13	3.86	3.26	0.59	Agree	Neutral	
17	2.59	2.26	0.35	Disagree	Extreme	
23	2.71	2.5	0.17	Disagree	Extreme	
28	2.21	2.23	0.01	Disagree	Neutral	*
Importance and contribution to society						
3	1	1.36	N/A	Disagree	N/A	*
7	5	4.29	N/A	Agree	N/A	
24	4.04	4.17	0.17	Agree	Neutral	
26	2.35	2.55	0.29	Disagree	Neutral	*
29	4.26	3.95	0.34	Agree	Neutral	
Difficulty						
4	4	3.31	N/A	Agree	N/A	
31	3.25	3.2	0.05	Agree	Neutral	*
33	2.44	2.6	0.14	Disagree	Neutral	*
Relationship to Math and Science						
6	4	3.92	N/A	Agree	N/A	
11	5	4.12	N/A	Agree	N/A	
16	1.63	1.9	0.27	Disagree	Neutral	*
27	3.69	3.48	0.23	Agree	Neutral	
34	4.65	3.89	0.86	Agree	Neutral	
Gender						
2	2	1.93	N/A	Disagree	N/A	*
8	5	4.46	N/A	Agree	N/A	
21	4.78	4.68	0.17	Agree	Neutral	
32	1.78	2.19	0.36	Disagree	Neutral	*
Connection to Problem Solving						
5	4	4.12	N/A	Agree	N/A	
18	1.92	1.95	0.03	Disagree	Neutral	*
30	3.07	3.1	0.04	Disagree	Extreme	
Problem Solving Capability						
9	4	3.3	N/A	Agree	N/A	
22	3.89	3.87	0.02	Agree	Neutral	
25	2.73	2.84	0.11	Disagree	Neutral	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

Class 2 showed larger effect sizes than Class 1. However, the criteria: learning interest, engineering and technology difficulty, connection to problem solving and problem solving capability showed no significant effect sizes.

Multidisciplinary Relationships: For all students in Class 2 Pre to Post, the largest effect size was 0.86 for statement 34. The post assessment administered at the end of the semester showed that 80% of the students thought math was used less in engineering and technology than originally thought before taking the class. This could be due to parts of the class activities that were conducted that minimally involved math, yet during the class visit there was a clear connection made to geometry when making airplanes. The students had to fold the cardboard cut out to a specific angle. Another suggestion was that students were beginning to understand that engineering and technology use a variety of thinking and analysis skills which incorporate math applications. There was evidence that this was the case during the class visits, because the students were left to follow the instructions using creativity and as discussed in Section 4.1.1 there were other analysis skills used.

While there was more variance in opinion after the class, overall the mean shifted from between agree and strongly agree to between neutral and agree about a connection to math and science. Although the results from statements 16 and 27 support the statement that math and science disciplines have connection with engineering and technology, the connection was less strong than originally anticipated. In addition, the higher variance in opinion was interesting; it seemed that the class experience influenced the opinion, but the influence may not have been in a consistent direction. In relation to the research questions, it was clear that the students did see a connection between engineering, technology, math, and science, however, it was unclear why the perception of this connection decreased over the term.

Career Interest: An effect size of 0.59 for Statement 13 showed a decreased intensity of the mean response to be below more than 70% of the students' pre agreement that having a job in engineering or technology would be fun. While this change was not extreme, it was in the opposite direction of what one might seek to expect. The other statements in this section were also in a direction showing less career interest. In particular the students disagreed with the three other positively worded statements. The agreement with statement 13 that it would be fun was confirmed by the disagreement with statement 28 that it would be dull and boring. From these statements it seemed that the students did agree that it might be fun, but still were not very interested. The results did not delineate whether this was because being fun was not important to students, or because there were alternative careers which may be more fun. The student responses during class visits suggested some of the students were interested in becoming an engineer or technologist, i.e., one student stated he wanted to be an engineer when he grows up. In addition, insight into motives for picking a career was given by a student who stated he wanted to be a doctor, because he wanted to be rich. This suggested that the students could consider a career in technology or engineering as fun, but merely being fun was not the motive to select a career. The research question was answered that students were not interested in a career in engineering or technology based only on the motivation of having a fun career. Further investigation of student career choice motives would be insightful.

Gender: The next highest effect size resulted from Statement 32. This effect showed that the student's perception of females and males being fit for engineering and technology increased. During the class visits, it was clear that the behavior of the teacher supported the perception as there was no evidence of treating female students differently than males. While this does not give a definite answer, it does provide insight into the effect of the gender of teacher mentioned in the second research question.

Importance of contribution to society: There was a consistent perception of engineering and technology having a significant and positive contribution to society. In the classroom, there were products of engineering such as carpentry made by other students and pictures of airplanes on the wall. This allowed the students to perceive a connection even during the first two weeks of the term. The decrease in perception indicated by the statements in this category, suggested that other experiences during class may have affected the initial less informed perception

Table 4-5: Pre to post test comparison for students in Class 3

S #[1]	Pre Mean[2]	Post Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.41	2.28	0.11	Disagree	Extreme	*
12	3.09	3.12	0.03	Agree	Extreme	
14	3.53	3.46	0.07	Agree	Neutral	
15	2.61	2.72	0.11	Disagree	Neutral	*
19	3.50	3.26	0.23	Agree	Neutral	
20	2.82	2.56	0.20	Disagree	Extreme	
Interest in career						
10	2.86	2.72	0.12	Disagree	Extreme	
13	3.56	3.46	0.10	Agree	Neutral	
17	2.32	2.58	0.24	Disagree	Extreme	
23	2.42	2.55	0.11	Disagree	Neutral	
28	2.20	2.21	0.01	Disagree	Neutral	*
Importance and contribution to society						
3	1.49	1.37	0.13	Disagree	Extreme	*
7	3.88	4.22	0.44	Agree	Extreme	
24	3.36	3.62	0.31	Agree	Extreme	
26	1.80	2.16	0.42	Disagree	Neutral	*
29	3.68	3.82	0.17	Agree	Extreme	
Difficulty						
4	3.40	3.03	0.37	Agree	Neutral	
31	3.15	2.94	0.18	Shifting	Neutral	*
33	2.86	2.76	0.08	Disagree	Extreme	*
Relationship to Math and Science						
6	4.00	3.93	0.08	Agree	Neutral	
11	4.19	3.92	0.31	Agree	Neutral	
16	1.64	1.61	0.03	Disagree	Extreme	*
27	3.74	3.79	0.07	Agree	Extreme	
34	4.00	4.15	0.20	Agree	Extreme	
Gender						
2	1.63	1.33	0.36	Disagree	Extreme	*
8	4.65	4.55	0.13	Agree	Neutral	
21	4.73	4.78	0.10	Agree	Extreme	
32	1.40	1.50	0.11	Disagree	Neutral	*
Connection to Problem Solving						
5	3.86	3.89	0.04	Agree	Extreme	
18	1.94	2.18	0.21	Disagree	Neutral	*
30	2.45	2.68	0.24	Disagree	Neutral	
Problem Solving Capability						
9	3.44	3.47	0.03	Agree	Extreme	
22	3.57	3.89	0.40	Agree	Extreme	
25	2.58	2.44	0.15	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two
Negatively stated criteria in survey.

All students in Class 3 Pre to Post test, the response data consistently showed practically insignificant effect sizes for four of the measurement criteria—interest in learning, interest in career, relationship to math and science, and connection to problem solving.

Importance and Contribution to Society: Three of the five statements with the highest significance were related to society. The highest significance was Statement 7 showing an average post perception that engineers and technologist help make people's lives better that was greater than 65% of the students' pre responses. This change in combination with the weakened disagreement that technology and engineering have provided society with more bad things than good things (Statement 26: effect size 0.42, >66%) suggests that the class helped them understand advances in technology have allowed people to do both good and bad. All of the five statements in this criterion confirm the trend of students' agreement with positively worded statements and disagreement with negatively worded statements. These results confirmed the students' positive perception of technology and engineering's importance and contribution to society.

Difficulty of Engineering and Technology: Statement 31 that to become an engineer or technologist, you have to take hard classes, was particularly interesting for this class as the perception shifted from agree to disagree. The responses showed the students' confidence increased or perception of difficultly decreased with the classroom experiences. The effect size was small (0.18, >54%), but the practical significance was high as there was a change in opinion.

Gender: The students showed perception opposing changes about how well females and males are fit for engineering and technology. While the directions of change were inconsistent, the overall perception was that both genders were fit for engineering and technology shown by the students agreeing with statements 8 and 21 (girls can be as successful as boys at engineering and technology and girls can have a technical job) and disagreeing with statements 2 and 32 (boys are better and know more about engineering and technology) . In addition, the perception changes were towards a more consist perception of that equality. For example, during the pre surveys the students' opinion varied from neutral by 30% more than during the post survey.

Table 4-6: Pre to post test comparison for students in Class 4

S #[1]	Pre Mean[2]	Post Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.25	2.67	0.37	Disagree	Neutral	*
12	2.76	3.34	0.58	Shifting	Extreme	
14	3.89	3.89	0.00	Agree	No Δ	
15	2.86	2.63	0.19	Disagree	Extreme	*
19	3.66	3.14	0.52	Agree	Neutral	
20	2.80	2.63	0.15	Disagree	Extreme	
Interest in career						
10	3.05	2.71	0.31	Shifting	Extreme	
13	3.55	3.38	0.16	Agree	Neutral	
17	2.00	2.18	0.18	Disagree	Neutral	
23	2.35	2.39	0.05	Disagree	Neutral	
28	2.42	2.19	0.25	Disagree	Extreme	*
Importance and contribution to society						
3	1.25	1.54	0.33	Disagree	Neutral	*
7	4.14	4.37	0.28	Agree	Extreme	
24	3.74	3.74	0.01	Agree	No Δ	
26	2.46	2.14	0.30	Disagree	Extreme	*
29	3.90	4.12	0.27	Agree	Extreme	
Difficulty						
4	3.00	3.13	0.13	Shifting	Extreme	
31	2.86	3.00	0.13	Shifting	Neutral	*
33	2.77	2.68	0.08	Disagree	Extreme	*
Relationship to Math and Science						
6	3.97	4.23	0.34	Agree	Extreme	
11	4.08	3.95	0.17	Agree	Neutral	
16	1.75	1.70	0.06	Disagree	Extreme	*
27	3.67	3.91	0.27	Agree	Extreme	
34	4.00	4.37	0.42	Agree	Extreme	
Gender						
2	2.22	1.60	0.60	Disagree	Extreme	*
8	4.43	4.61	0.23	Agree	Extreme	
21	4.71	4.58	0.18	Agree	Neutral	
32	1.85	1.71	0.13	Disagree	Extreme	*
Connection to Problem Solving						
5	4.44	4.40	0.06	Agree	Neutral	
18	1.46	1.87	0.50	Disagree	Neutral	*
30	3.19	3.12	0.06	Agree	Neutral	
Problem Solving Capability						
9	3.14	3.17	0.03	Agree	Extreme	
22	3.72	3.74	0.02	Agree	Extreme	
25	2.93	2.70	0.28	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

Similar to Class 3, Class 4 was not visited and no data is available for the added insight from discussion with students and observations of their experiences. The survey responses showed at least small practical significant differences for all eight criteria except problem solving capability. In fact, three effect sizes were found to be above 0.50.

Gender: For Statement 2, the mean shifted from between disagree and neutral to between strongly disagree and disagree with the idea that males were better at being engineers than females. This trend was in the direction that one would like for students to perceive. The other four statements in the gender category confirmed this opinion and 3 of the 4 confirmed the shift to a more extreme opinion. Statement 21 did not confirm the trend as the students felt less confident that a female could have a technical job. It is important to note the student initially agreed with Statement 21 more strongly than Statement 2 and the change in perceptions made the extremeness of opinion shift toward more similarities.

Interest in learning: The next two greatest effect sizes were 0.58, >70%, for Statement 12 and 0.52 ,>70%),for Statement 19. Reponses to 12 showed the students shifted from between neutral and disagree (closer to neutral) in opinion of being able to do well in an advanced technology and engineering class to between strongly disagree and disagree (closer to strongly disagree). This shift showed a mean of more strongly disagree than more than 70% of the pre responses. In addition, it showed higher consistency with four of the five statements about interest in learning. The exception, statement 20, was about joining a club rather than taking a class and could suggest that there were other barriers besides interest in learning through joining clubs that are not explored in this survey. The responses to Statement 19 showed a shift to agree less strongly with an interest to learn more about engineering and technology. This could suggest that the students learned what they were interested in learning or what they learned actually decreased their interest in learning more. The opinions expressed through the other statements confirm that it was likely the former.

Connection to Problem Solving: Another significant effect size was 0.50 for Statement 18. The new mean response showed that the students disagreed less strongly during their post responses than nearly 70% of the students disagreed in the pre responses with the idea that one does not have to problem solve to be an engineer or technologist. This change was not companioned by similar effect sizes for the other two statements about problem solving connection, but the opinion was consistent.

Along with these effect sizes of 0.50 and above, there were three other statements with significant changes, because the opinion shifted: Statement 10 (interest in career), 4, and 31 (both difficulty).

Interest in career: The post class survey of Statement 10 suggested the students disagreed with pursuing a job with a lot of engineering and technology rather than agree as they had at the beginning of class. This change might not be considered to be very significant as they had barely agreed (3.05) before and the other statements do not show a clear pattern of opinion.

Difficulty: Statements 4 and 31 are particularly interesting as the changes are of the same magnitude. Overall their perception is that they are not sure if you have to take hard classes, but they are sure you had to be smart maybe even very smart to be an engineer or technologist. This might be the ideal perception—that the classes are doable, but the position requires intelligence. It would be great if this perception could have been combined with a perception of interest in career, but as mentioned above the opinion about career was unclear.

Relationship to Math and Science: The students perceive a connection between math, science, engineering, and technology. All 5 statements in this criterion confirm their perception. Notable perceptions changes include statements 6, 27, and 34 and indicate that the students saw a greater connection between these disciplines after having taken the Technology Education rotation of their course.

Importance and contribution to society: The students perceive a connection between engineering, technology, and society. In addition, they perceive this connection as positive. There were four effect sizes in the range of 0.25 to 0.33 suggesting that the students saw a greater and more positive connection.

4.3.3 Gender of Teacher Trends

The following tables show a comparison of the survey results for students separated by the gender of their teacher. Below the tables is the discussion of this comparison group.

Table 4-7: Pre to post test comparison for all students with a male teacher

S #[1]	Pre Mean[2]	Post Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.28	2.51	0.20	Disagree	Neutral	*
12	3.19	3.34	0.15	Agree	Extreme	
14	3.96	3.97	0.01	Agree	Extreme	
15	2.60	2.63	0.03	Disagree	Neutral	*
19	3.70	3.27	0.44	Agree	Neutral	
20	2.89	2.66	0.20	Disagree	Extreme	
Interest in career						
10	3.00	2.74	0.25	Shifting	Extreme	
13	3.70	3.34	0.35	Agree	Neutral	
17	2.29	2.21	0.08	Disagree	Extreme	
23	2.52	2.43	0.08	Disagree	Extreme	
28	2.31	2.21	0.11	Disagree	Extreme	*
Importance and contribution to society						
3	1.24	1.47	0.29	Disagree	Neutral	*
7	4.17	4.34	0.22	Agree	Extreme	
24	3.90	3.90	0.01	Agree	No Δ	
26	2.40	2.29	0.13	Disagree	Extreme	*
29	4.07	4.06	0.01	Agree	Neutral	
Difficulty						
4	3.04	3.20	0.15	Agree	Extreme	
31	3.07	3.07	0.01	Agree	No Δ	*
33	2.60	2.65	0.04	Disagree	Neutral	*
Relationship to Math and Science						
6	3.97	4.11	0.19	Agree	Extreme	
11	4.11	4.02	0.13	Agree	Neutral	
16	1.69	1.77	0.09	Disagree	Neutral	*
27	3.68	3.75	0.08	Agree	Extreme	
34	4.31	4.21	0.11	Agree	Neutral	
Gender						
2	2.21	1.73	0.47	Disagree	Extreme	*
8	4.45	4.56	0.14	Agree	Extreme	
21	4.75	4.61	0.19	Agree	Neutral	
32	1.81	1.87	0.06	Disagree	Neutral	*
Connection to Problem Solving						
5	4.42	4.29	0.19	Agree	Neutral	
18	1.69	1.90	0.21	Disagree	Neutral	*
30	3.13	3.11	0.01	Agree	Neutral	
Problem Solving Capability						
9	3.17	3.22	0.05	Agree	Extreme	
22	3.80	3.78	0.02	Agree	Neutral	
25	2.84	2.75	0.10	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

When analyzing the responses from all students with a male teacher, there were several measurement criteria without any effect sizes above 0.30. These were importance and contribution to society, difficulty, relationship to math and science, connection to problem solving, and problem solving capability.

Gender: The largest magnitude size for any statement when comparing students of male teachers answers Pre to Post is 0.47. This was within the small effect range, but suggests a post mean greater than nearly 70% of the pre responses. It showed a slight decrease in agreement with the statement that males were better than females at being engineers. The means changed from 2.21 to 1.73 (between disagree and neutral to between disagree and strongly disagree). The change has medium significant practical significance even though the effect size is small. The opinion was consistent with the other three statements about gender—it was clear that the students felt that engineering and technology were appropriate for both females and males. During the visits to the classroom of a male teacher, there was no notable difference between the male and female students' capabilities during their projects. For the car crash test project, both male and female students could describe their successes on the same levels of the car test ramp. Again as when discussing student perceptions overall, this general agreement that both females and males are fit for engineering is promising.

Interest in learning: The responses to statement 19 had an effect size of 0.44 showing a lower desire to learn more about engineering and technology in students post the class experience than more than 65% of students before the class experiences. The post response decrease could be attributed to currently being engaged in the learning process for engineering and technology; since consistent interest remained in learning for all statements except the one associated with joining a club. This is also the same trend seen when looking at the responses from all students—general learning interest.

Interest in career: The responses showed only one effect size greater than 0.30, 62%, and that was for statement 13. An additional practically significant perception change was suggested by statement 10, as the students changed from being neutral to disagreeing, effect size 0.25, >60%. Even with these two statements, the students' perception was shown by the survey as inconsistent. In combination with student comments during the class visits, this could be explained by the variance in opinion within male students. While there were some students strongly interested in being an engineer or technologist as evidenced by a male student saying "I want to be an engineer." There were students less interested or uninterested who responded with interests in being a surgeon, chef, and dentist.

Importance and Contribution to Society: The students with a male teacher felt that engineering and technology are important to society. Both pre and post, the students' strongest perception in this section was about statement 3—strongly disagree that engineering and technology have nothing to do with live.

Difficulty: The responses from the three statements show that the students do think one has to be very smart, but one does not have take hard classes to be a engineer or technologist.

Relationship to Math and Science: Just as with all students, students with a male teacher see a connection of similar strength for math and science to engineering and technology. When comparing the statements about math to those about science, it seems that the students' perceptions of the connection to science increased more significantly pre to post than the students' perceptions of the connection to math.

Connection to Problem Solving: In addition, the students perceive a connection between engineering and technology. This connection is stronger for students with a male teacher than students overall as indicated by a slight agreement that 'When they think of engineering and technology, they mostly think of solving problems.'

Problem Solving Capability: The students with a male teacher responded that they feel confident about solving problems. This section showed low effect sizes most consistently suggesting that the class experiences had the smallest effect on students perception about problem solving capability when compared with the other seven measurement criteria.

Table 4-8: Pre to post test comparison for all students with a female teacher

S #[1]	Pre Mean[2]	Post Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.42	2.36	0.04	Disagree	Extreme	*
12	3.02	3.03	0.01	Agree	Extreme	
14	3.71	3.69	0.02	Agree	Neutral	
15	2.41	2.45	0.04	Disagree	Neutral	*
19	3.36	3.26	0.09	Agree	Neutral	
20	2.65	2.55	0.08	Disagree	Extreme	
Interest in career						
10	2.73	2.68	0.05	Disagree	Extreme	
13	3.44	3.40	0.04	Agree	Neutral	
17	2.31	2.40	0.09	Disagree	Neutral	
23	2.37	2.41	0.04	Disagree	Neutral	
28	2.48	2.51	0.02	Disagree	Neutral	*
Importance and contribution to society						
3	1.53	1.49	0.05	Disagree	Extreme	*
7	4.01	4.14	0.16	Agree	Extreme	
24	3.59	3.67	0.08	Agree	Extreme	
26	2.01	2.14	0.16	Disagree	Neutral	*
29	3.82	3.87	0.06	Agree	Extreme	
Difficulty						
4	3.13	2.97	0.15	Shifting	Neutral	
31	3.15	3.06	0.09	Agree	Neutral	*
33	2.62	2.58	0.03	Disagree	Extreme	*
Relationship to Math and Science						
6	3.92	3.89	0.03	Agree	Neutral	
11	4.19	4.08	0.13	Agree	Neutral	
16	1.65	1.64	0.01	Disagree	Extreme	*
27	3.85	3.87	0.03	Agree	Extreme	
34	4.07	4.13	0.07	Agree	Extreme	
Gender						
2	1.63	1.51	0.13	Disagree	Extreme	*
8	4.55	4.50	0.06	Agree	Neutral	
21	4.59	4.61	0.02	Agree	Extreme	
32	1.73	1.77	0.04	Disagree	Neutral	*
Connection to Problem Solving						
5	3.91	3.92	0.01	Agree	Extreme	
18	1.86	1.95	0.10	Disagree	Neutral	*
30	2.78	2.88	0.10	Disagree	Neutral	
Problem Solving Capability						
9	3.42	3.43	0.01	Agree	Extreme	
22	3.61	3.74	0.14	Agree	Extreme	
25	2.66	2.61	0.05	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

For all students with a Female Teacher Pre to Post, there were no effect sizes above 0.16. This suggests that the mean post response remained at most higher than 55% of the students pre responses and thus a change of little practical significance based on effect size alone. There was one statement, statement 4, that suggested practical significance about changing perceptions of difficulty by an opinion shift.

Difficulty: There was a shift in opinion from agreement to disagreement with Statement 4—to be good at engineering or technology you have to be very smart. This change was only confirmed by opinion and direction of change for one of two other statements in this section and thus cannot lead to a clear conclusion about opinion or Pre to Post changes. During the class visits, the students most often replied that they thought the class was easy and fun. The students' perception of ease may have influenced the necessity for being 'very smart.' Confounding between the perceptions of difficulty and of being fun makes the qualitative data about difficulty of engineering and technology unclear as reflected in the survey results. A stronger understanding of the interplay of these two perceptions along with more observations and student survey information could help clarify this uncertainty. Overall, the students with a female teacher thought that one does have to be smart, but probably not 'very smart' and might have to take hard classes to be an engineer and technologist.

Interest in Learning: The learning interest of students with a female teacher was just like students overall and with a male teacher—agreement of interest in learning as long as it is not a club.

Interest in Career: Again there is a parallel with the students overall, students with a female teacher do not necessarily want to be an engineer or technologist, but the jobs of engineers and technologist are fun rather than dull and boring in their opinion.

Importance and Contribution to Society: The students with a female teacher felt that engineering and technology are important to society.

Relationship to Math and Science: Just as with all students, students with a female teacher see a connection of similar strength for math and science to engineering and technology.

Connection to Problem Solving: In addition, the students perceive a connection between engineering and technology. This connection is weaker for students with a female teacher than students with a male teacher.

Problem Solving Capability: The students with a female teacher responded that they feel confident about solving problems.

Additional Insights: The small effect sizes suggested that female teachers have less effect on student perception or that the effect occurred during the first weeks of class prior to the Pre-survey. When comparing the teacher involvement with the students, the female and male teacher seemed to have similar roles and involvement with the students during projects—after having given basic instructions the students worked independently from the teacher unless students asked for help or seemed to stop making progress and the teacher noticed. This suggested that the difference was likely not due to a difference in teacher gender behavior patterns, but rather other factors unapparent during class visits. In addition, the female teacher influence made within the first weeks of the class could not be investigated through the surveying procedure of this study.

Table 4-9: Pre-test students with a female teacher compared with a male teacher

S #[1]	Female Mean[2]	Male Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.42	2.28	0.12	Disagree	Extreme	*
12	3.02	3.19	0.15	Agree	Neutral	
14	3.71	3.96	0.27	Agree	Extreme	
15	2.41	2.60	0.18	Disagree	Neutral	*
19	3.36	3.70	0.32	Agree	Extreme	
20	2.65	2.89	0.19	Disagree	Neutral	
Interest in career						
10	2.73	3.00	0.24	Shifting	Neutral	
13	3.44	3.70	0.26	Agree	Extreme	
17	2.31	2.29	0.02	Disagree	Extreme	
23	2.37	2.52	0.13	Disagree	Neutral	
28	2.48	2.31	0.16	Disagree	Extreme	*
Importance and contribution to society						
3	1.53	1.24	0.31	Disagree	Extreme	*
7	4.01	4.17	0.19	Agree	Extreme	
24	3.59	3.90	0.33	Agree	Extreme	
26	2.01	2.40	0.48	Disagree	Neutral	*
29	3.82	4.07	0.28	Agree	Extreme	
Difficulty						
4	3.13	3.04	0.08	Agree	Neutral	
31	3.15	3.07	0.08	Agree	Neutral	*
33	2.62	2.60	0.02	Disagree	Extreme	*
Relationship to Math and Science						
6	3.92	3.97	0.05	Agree	Extreme	
11	4.19	4.11	0.10	Agree	Neutral	
16	1.65	1.69	0.04	Disagree	Neutral	*
27	3.85	3.68	0.20	Agree	Neutral	
34	4.07	4.31	0.29	Agree	Extreme	
Gender						
2	1.63	2.21	0.56	Disagree	Neutral	*
8	4.55	4.45	0.13	Agree	Extreme	
21	4.59	4.75	0.23	Agree	Extreme	
32	1.73	1.81	0.08	Disagree	Neutral	*
Connection to Problem Solving						
5	3.91	4.42	0.65	Agree	Extreme	
18	1.86	1.69	0.17	Disagree	Extreme	*
30	2.78	3.13	0.37	Shifting	Neutral	
Problem Solving Capability						
9	3.42	3.17	0.27	Agree	Neutral	
22	3.61	3.80	0.21	Agree	Extreme	
25	2.66	2.84	0.18	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of “I do not know” were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

When comparing students with a female teacher to those with a male teacher, there were no practical significant perception changes about interest in career, difficulty, relationship to math and science, and problem solving capability.

Connection to Problem Solving: Pre survey responses yielded an effect size of 0.65 showing that the mean response from students with a male teacher showed a greater connection with engineers and technologist solving problems than nearly 75% of the students with a female teacher. The significance of the influence of the teacher's gender in this category was confirmed by a shifting opinion in statement 30—"when I think of engineering and technology, I mostly think of solving problems." Students with a male teacher agreed with this statement and students with a female teacher disagreed. Overall, the students with a male teacher showed a greater connection to problem solving at the beginning of the class. This suggested that students connected problem solving with males more than females and based on their teacher's gender, but there was not apparent evidence to support this suggestion. The variation of school districts of reduced the chances that the students' previous schooling experiences could have resulted in this perception difference.

Gender: An effect size of 0.56 was found for Statement 2. It showed that students with a female teacher disagreed more strongly on average that males were better than females at engineering than more than 70% of students with a male teacher. This pattern was confirmed with the other negatively worded statement—that "boys know more about engineering and technology than girls." The data showed that the students with male teachers had similar opinions—these students disagreed with those two statements and actually agreed more strongly with statements that presented equality such as, "a girl can have a technical job." The décor on the walls of the female teacher's classroom depicted females working in engineering and technology, which would have reinforced the perception already established by having a female teacher—that both females and males can do engineering and technology.

Importance and contribution to society: The students with a female teacher perceived the contribution that engineering and technology make to society as less important as well as less positive. All of the statements in this criterion confirmed this perception and Statements 3, 24, and 26 indicated that gender of teacher had a small effect. The reason for the perception difference was unclear as no qualitative data explained or confirmed this difference.

Interest in Learning: There was one significant effect size (0.32) in this measurement criterion—Statement 19. The response to this statement indicated that the mean response from students with a male teacher suggested a higher interest to learn more about engineering and technology at school than not quite 65% of students with a female teacher. This higher learning interest was not confirmed by all the statements in the criterion and thus it suggested that the overall learning interest of the students was not distinctly different based on the teacher's gender., The class visits did not confirm this small effect size difference, as more students with a female teacher indicated that they would be taking another technology or engineering class. This aspect of the qualitative data might be skewed as the female teacher seemed to teach a greater variety of additional technology and engineering class than the male teacher. Therefore, the results may be attributed to additional technology and engineering class offerings at the school rather than overall interest to pursue learning in these areas.

Table 4-10: Post-test students with a female teacher compared with a male teacher

S #[1]	Female Mean[2]	Male Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.36	2.51	0.11	Disagree	Neutral	*
12	3.03	3.34	0.28	Agree	Extreme	
14	3.69	3.97	0.32	Agree	Extreme	
15	2.45	2.63	0.17	Disagree	Neutral	*
19	3.26	3.27	0.01	Agree	Extreme	
20	2.55	2.66	0.09	Disagree	Neutral	
Interest in career						
10	2.68	2.74	0.06	Disagree	Neutral	
13	3.40	3.34	0.05	Agree	Neutral	
17	2.40	2.21	0.19	Disagree	Extreme	
23	2.41	2.43	0.01	Disagree	Neutral	
28	2.51	2.21	0.30	Disagree	Extreme	*
Importance and contribution to society						
3	1.49	1.47	0.01	Disagree	Extreme	*
7	4.14	4.34	0.25	Agree	Extreme	
24	3.67	3.90	0.24	Agree	Extreme	
26	2.14	2.29	0.16	Disagree	Neutral	*
29	3.87	4.06	0.21	Agree	Extreme	
Difficulty						
4	2.97	3.20	0.22	Shifting	Extreme	
31	3.06	3.07	0.01	Agree	Extreme	*
33	2.58	2.65	0.06	Disagree	Neutral	*
Relationship to Math and Science						
6	3.89	4.11	0.25	Agree	Extreme	
11	4.08	4.02	0.07	Agree	Neutral	
16	1.64	1.77	0.14	Disagree	Neutral	*
27	3.87	3.75	0.14	Agree	Neutral	
34	4.13	4.21	0.09	Agree	Extreme	
Gender						
2	1.51	1.73	0.24	Disagree	Neutral	*
8	4.50	4.56	0.06	Agree	Extreme	
21	4.61	4.61	0.01	Agree	No Δ	
32	1.77	1.87	0.09	Disagree	Neutral	*
Connection to Problem Solving						
5	3.92	4.29	0.48	Agree	Extreme	
18	1.95	1.90	0.05	Disagree	Extreme	*
30	2.88	3.11	0.23	Shifting	Neutral	
Problem Solving Capability						
9	3.43	3.22	0.22	Agree	Neutral	
22	3.74	3.78	0.05	Agree	Extreme	
25	2.61	2.75	0.15	Disagree	Neutral	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

The Post comparison showed the most significant effect size with the connection to problem solving criterion of 0.48. In addition, measurement criteria without practical significance indicated by effect sizes was shown for interest in career, importance and contribution to society, relationship to math and science, gender, and problem solving capability .

Problem Solving Connection: The largest effect size, 0.48, >66%, indicated that students with a male teacher on average saw a greater connection with engineers and technologist solving problems which agreed with results from the Pre surveys. This showed that male teacher students' perceptions of the connection was stronger than students with a female teacher and was confirmed by Statement 18 results. Results within this criterion were the same shifting opinion that the Pre surveys showed and appeared more extreme. Students with a male teacher agreed more strongly and students with a female teacher disagreed more strongly with Statement 30 - "when I think of engineering and technology, I mostly think of solving problems." During classroom observations, the students with a male teacher worked in larger groups which may have allowed greater insight and discussions into varying perceptions of problems.

Interest in Learning: In general, students with a male teacher agreed more strongly with positively worded statements, but disagreed less strongly with negatively worded statements. The former (more strongly agreeing with positive) was more extreme. This indicated that, even after having taken the class, students of a male teacher were more interested in learning about engineering and technology. This could suggest an experience in technology and engineering provided a platform to seek for more information, while students with a female teacher obtained sufficient experiences to meet their current needs. However, the observation was not confirmed since all students generally agreed with an interest in learning more as long as it was not by joining a club.

Difficulty: There was a shifting opinion associated with Statement 4—students with a female teacher slightly disagreed that ‘to be good at engineering or technology you have to be very smart’, while students with a male teacher agreed. There was not a clear pattern within the criteria about difficulty and thus it was hard to determine what the shift could signify. Observations that students with a female teacher asked for teacher guidance less often on projects than the students with a male teacher added to the perspective of difficulty by suggesting that the tasks were less clear or harder for the students to complete. One might consider the difference in the number of students asking the teacher questions was due to the female teacher being less approachable, but there was evidence to suggest that this is not the case as the female teacher interacted with her students just as often as the male teacher did. The female teacher’s conversation included guidance on how to complete a task less often than the male teacher’s conversations.

4.3.4 Gender of Student Trends

The following tables show a comparison of the survey results for students separated by the gender of the student. Below the tables is the discussion of this comparison group.

Table 4-11: Pre and post survey comparison of all female students

S #[1]	Pre Mean[2]	Post Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.56	2.84	0.26	Disagree	Neutral	*
12	2.75	2.90	0.13	Disagree	Neutral	
14	3.57	3.72	0.15	Agree	Extreme	
15	2.64	2.65	0.01	Disagree	Neutral	*
19	3.29	3.02	0.25	Agree	Neutral	
20	2.46	2.29	0.14	Disagree	Extreme	
Interest in career						
10	2.56	2.38	0.17	Disagree	Extreme	
13	3.39	3.12	0.25	Agree	Neutral	
17	2.03	1.99	0.04	Disagree	Extreme	
23	2.14	2.05	0.09	Disagree	Extreme	
28	2.47	2.59	0.10	Disagree	Neutral	*
Importance and contribution to society						
3	1.40	1.54	0.15	Disagree	Neutral	*
7	4.01	4.12	0.12	Agree	Extreme	
24	3.59	3.79	0.23	Agree	Extreme	
26	2.02	2.10	0.10	Disagree	Neutral	*
29	3.87	3.86	0.01	Agree	Extreme	
Difficulty						
4	3.04	2.93	0.11	Shifting	Extreme	
31	2.77	2.98	0.20	Disagree	Neutral	*
33	2.77	2.63	0.13	Disagree	Extreme	*
Relationship to Math and Science						
6	3.81	3.89	0.09	Agree	Extreme	
11	4.15	4.03	0.16	Agree	Neutral	
16	1.86	1.73	0.14	Disagree	Extreme	*
27	3.66	3.73	0.08	Agree	Neutral	
34	4.13	4.10	0.04	Agree	Neutral	
Gender						
2	1.48	1.33	0.21	Disagree	Extreme	*
8	4.79	4.65	0.22	Agree	Neutral	
21	4.81	4.59	0.30	Agree	Neutral	
32	1.40	1.62	0.22	Disagree	Neutral	*
Connection to Problem Solving						
5	3.94	3.94	0.00	Agree	No Δ	
18	1.77	1.94	0.19	Disagree	Neutral	*
30	2.63	3.01	0.36	Shifting	Neutral	
Problem Solving Capability						
9	3.44	3.27	0.19	Agree	Neutral	
22	3.73	3.70	0.03	Agree	Neutral	
25	2.80	2.71	0.09	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

When comparing responses of female students Pre (during the first two weeks) and Post (during the last two weeks) of the Technology Education rotation, there were only small effect sizes in two measurement criterion—gender and connection to problem solving. There were also shifting opinions in two—difficulty and connection to problem solving. The other five criteria did not show significant response changes—interest in learning, interest in career, importance and contribution to society, relationship to math and science, problem solving capability.

Gender: Overall the female students perceive that both females and males are fit for engineering and technology. The four statements relating to gender yielded effect sizes of 0.21, 0.22 (2), and 0.30, all but one showing about an increase in perception that boys are more knowledgeable about, or more fit for engineering and technology than girls by more than 60% of the students. This was opposite of the ideal trend towards an increased confidence for the girls to seek a career in engineering and technology. During the class visits, discussion on perception of this topic may have been reserved and negative comments may not have been expressed, because the interviewer (PI) was a female engineering student. The increase in gender bias toward males in engineering and technology was not due to an increased perception of class difficulty as the female students perceived that it was less difficult after having taken the class.

Difficulty: While during the first two weeks of the class, females perceived a slight level of difficulty associated with the engineering and technology type classes and the need to be smart to be successful in these fields After having taken the class the female students' perception was similar yet with less conviction towards the intensity of intelligence required.

Connection to Problem Solving: After having taken the class the female students became more neutral in perceptions about connection to problem solving as indicated by Statement 18 and 30. There opinion on statement 30 actually shifted from disagree to basically neutral that “When I think of engineering and technology, I mostly think of solving problems.”

Interest in Learning: Females students respond with a willingness to take another class in engineering and technology and would like to learn more, but do not think they would do well in an advanced engineering and technology course nor would they like to join an engineering and technology club.

Interest in Career: Again there is a parallel with the students overall, female students do not necessarily want to be an engineer or technologist, but the jobs of engineers and technologist are fun rather than dull and boring in their opinion.

Importance and Contribution to Society: The female students felt that engineering and technology are important to society.

Relationship to Math and Science: Just as with all students, female students see a connection of similar strength for math and science to engineering and technology.

Problem Solving Capability: The female students responded that they feel confident solving problems.

Table 4-12: Pre and post survey comparison of all male students

S #[1]	Pre Mean[2]	Post Mean[2]	Effect Size[3]	Opinion[4]	Change[5]	
Interest in learning						
1	2.18	1.90	0.25	Disagree	Extreme	*
12	3.33	3.51	0.18	Agree	Extreme	
14	3.90	3.95	0.05	Agree	Extreme	
15	2.18	2.28	0.10	Disagree	Neutral	*
19	3.87	3.67	0.21	Agree	Neutral	
20	3.16	3.05	0.09	Agree	Neutral	
Interest in career						
10	3.42	3.29	0.13	Agree	Neutral	
13	3.77	3.77	0.00	Agree	No Δ	
17	2.59	2.90	0.35	Disagree	Neutral	
23	2.77	3.06	0.26	Shifting	Neutral	
28	2.15	2.15	0.01	Disagree	No Δ	*
Importance and contribution to society						
3	1.38	1.40	0.02	Disagree	Neutral	*
7	4.06	4.39	0.45	Agree	Extreme	
24	3.73	3.74	0.02	Agree	Extreme	
26	2.05	2.33	0.31	Disagree	Neutral	*
29	3.87	4.08	0.25	Agree	Extreme	
Difficulty						
4	3.68	3.27	0.37	Agree	Neutral	
31	3.59	3.22	0.41	Agree	Neutral	*
33	2.50	2.52	0.01	Disagree	Neutral	*
Relationship to Math and Science						
6	4.23	4.11	0.15	Agree	Neutral	
11	4.29	4.09	0.24	Agree	Neutral	
16	1.60	1.70	0.10	Disagree	Neutral	*
27	3.79	3.98	0.21	Agree	Extreme	
34	4.27	4.21	0.07	Agree	Neutral	
Gender						
2	2.44	2.10	0.31	Disagree	Extreme	*
8	4.22	4.29	0.09	Agree	Extreme	
21	4.47	4.62	0.23	Agree	Extreme	
32	1.94	2.19	0.23	Disagree	Neutral	*
Connection to Problem Solving						
5	4.08	4.30	0.30	Agree	Extreme	
18	1.86	1.85	0.01	Disagree	Extreme	*
30	2.84	2.98	0.15	Disagree	Neutral	
Problem Solving Capability						
9	3.50	3.45	0.05	Agree	Neutral	
22	3.75	3.84	0.09	Agree	Extreme	
25	2.79	2.56	0.23	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

The largest magnitude effect size when comparing male students' answers Pre to Post was Statement 7 with 0.45, which was within the small effect range. There were no practical significant effect sizes in the criterion of interest in learning, interest in career, relationship to math and science, connection to problem solving, and problem solving capability.

Importance and contribution to society: The largest change of all male students showed a slight increase of the perception that engineers and technologist help make people's life better where the Post-test score increased from 4.06 (agree) to 4.39 (between agree and strongly agree). In the same category, importance and contribution to society, there were two additional statements with effect sizes of 0.25, 60%, or above. Results from Statement 29, confirmed that male students thought engineering and technology make lives more comfortable, 3.87 (between neutral and agree) to 4.08 (agree). Statement 26 in this criterion was negatively worded stating 'technology and engineering has brought about more bad things than good things'. The students disagreed with the statement, but shifted from 2.05 (disagree) to 2.33 (between disagree and neutral).

Difficulty: While the male students' Pre and Post surveys agreed to become an engineer or technologist, one would have to take hard classes, the level of agreement decreased (0.41 effect size suggesting a post mean was higher than approximately 66% of the students' pre responses). This seemed to suggest males students have a high level of confidence and regard for engineers and technologist.

Interest in Career: The responses about career interest suggested that the male students perceived it would be fun to have a career in engineering or technology

(Statements 10, 13 and 28), but they do not necessarily want to be an engineer or technologist (Statements 17 and 23). Of these statements one suggested a small perception change from the first two weeks to the last two weeks of the course—Statement 17, which was confirmed by a practically significant shifting opinion for Statement 23. These indicated male students were more interested in being an engineer or technologist after the course.

Gender: Showing only slight practical significance were the response changes corresponding to Statement 2. Male students agreed that both males and females were fit for technology and in general this perception became stronger.

Interest in Learning: Males students respond with a willingness to take another class in engineering and technology and would like to learn more. And unlike their female peers, they felt that they would do well in an advanced engineering and technology course and may like to join an engineering and technology club.

Interest in Career: Male students would like to be an engineer and think that engineers and technologist have fun jobs, but statement 17 shows that they would not like to be a technologist.

Relationship to Math and Science: Just as with all students, male students see a connection of similar strength for math and science to engineering and technology.

Connection to Problem Solving: The males students responded that there is a connection with solving problems, but problem solving is not all they think of when they think of engineering and technology.

Problem Solving Capability: The male students responded that they feel confident solving problems. Statements 9 and 22 responses show that the male students perceived themselves as bring good at solving problem in general and in everyday life.

Additional Insights: Overall male student response changes were smaller than that of females. In addition, unlike the female students, the male students had only one rather than five shifting opinions. This suggests that the male students' perceptions were less effected by classroom experiences. It would be interesting to understand if the classroom experiences could be changed to facilitate effects on male students' perceptions.

Table 4-13: Pre-test comparison of female students to male students

S #[1]	Female Mean[2]	Male Mean[2]	Effect Size[3]	Opinion[4]	Differ[5]	
Interest in learning						
1	2.56	2.18	0.35	Disagree	Extreme	*
12	2.75	3.33	0.51	Shifting	Extreme	
14	3.57	3.90	0.32	Agree	Extreme	
15	2.64	2.18	0.42	Disagree	Extreme	*
19	3.29	3.87	0.57	Agree	Extreme	
20	2.46	3.16	0.59	Shifting	Neutral	
Interest in career						
10	2.56	3.42	0.79	Shifting	Neutral	
13	3.39	3.77	0.38	Agree	Extreme	
17	2.03	2.59	0.57	Disagree	Neutral	
23	2.14	2.77	0.60	Disagree	Neutral	
28	2.47	2.15	0.30	Disagree	Extreme	*
Importance and contribution to society						
3	1.40	1.38	0.03	Disagree	Extreme	*
7	4.01	4.06	0.05	Agree	Extreme	
24	3.59	3.73	0.15	Agree	Extreme	
26	2.02	2.05	0.04	Disagree	Neutral	*
29	3.87	3.87	0.00	Agree	No Δ	
Difficulty						
4	3.04	3.68	0.61	Agree	Extreme	
31	2.77	3.59	0.84	Shifting	Extreme	*
33	2.77	2.50	0.23	Disagree	Extreme	*
Relationship to Math and Science						
6	3.81	4.23	0.52	Agree	Extreme	
11	4.15	4.29	0.20	Agree	Extreme	
16	1.86	1.60	0.27	Disagree	Extreme	*
27	3.66	3.79	0.14	Agree	Extreme	
34	4.13	4.27	0.14	Agree	Extreme	
Gender						
2	1.48	2.44	1.05	Disagree	Neutral	*
8	4.79	4.22	0.86	Agree	Neutral	
21	4.81	4.47	0.57	Agree	Neutral	
32	1.40	1.94	0.62	Disagree	Neutral	*
Connection to Problem Solving						
5	3.94	4.08	0.17	Agree	Extreme	
18	1.77	1.86	0.10	Disagree	Neutral	*
30	2.63	2.84	0.21	Disagree	Neutral	
Problem Solving Capability						
9	3.44	3.50	0.06	Agree	Extreme	
22	3.73	3.75	0.02	Agree	Extreme	
25	2.80	2.79	0.01	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

When comparing Pre survey response between female and male students, all criterion except importance of contribution to society, connection to problem solving, and problem solving confidence showed practically significant effect sizes.

Gender: Pre survey responses showed that females disagreed more strongly than males with the statement that "boys are better at being engineers than girls" (Statement 2) . The average female responses were between strongly disagree and disagree compared to between disagree and neutral for male students.

This statement had the largest effect size of 1.05, ~85%, with the next largest being 0.84, ~80%, for Statement 31. The females disagreed while the males agreed that to become an engineer or technologist, one would have to take hard classes. Also in the difficulty category, Statement 4 had an effect size of 0.61 indicating that based on their mean response females agreed less strongly with the need to be very smart to be successful at engineering or technology than nearly 75% of male students.

Difficulty: Statement 31 had a large effect size (0.84, ~80%) which indicated male students agreed while female students disagreed that 'to become an engineering or technologist you have to take hard classes.' Overall, male students perceived engineers and technologist as smarter than the female students' perception.

Interest in Career: The males agreed with having a desire to pursue a job with a lot of engineering and technology while the females were in disagreement that they would like that type of job. This was shown by the responses to Statement 10 with an effect size of 0.79, nearly 80%.

Interest in Learning: In addition to career interest, females had less learning interests in engineering and technology than the males. This difference in perception was most extreme in relation to joining a club about engineering and technology as female students would not join, while male students would.

Relationship to Math and Science: The greater learning interest of males was associated with their higher perception of connection between engineering, technology, math and science. The males had a higher perception of the connection between engineering, technology, math and science indicated by responses to all five statements in the measurement criteria about multidisciplinary relationships; one of which, Statement 6, showed a practically significant effect size. It was clear from the surveys that male students at the beginning of the class were more interested in learning about engineering and technology, believed that the importance and contribution to society was significant, saw a stronger connection to math and science, were weaker in perception of gender equality, and stronger in perception of problem solving capability than the female students..

Table 4-14: Post-test comparison of female students to male students

S #[1]	Female Mean[2]	Male Mean[2]	Effect Size[3]	Opinion[4]	Differ[5]	
Interest in learning						
1	2.84	1.90	0.83	Disagree	Extreme	*
12	2.90	3.51	0.55	Shifting	Extreme	
14	3.72	3.95	0.26	Agree	Extreme	
15	2.65	2.28	0.35	Disagree	Extreme	*
19	3.02	3.67	0.61	Agree	Extreme	
20	2.29	3.05	0.63	Shifting	Neutral	
Interest in career						
10	2.38	3.29	0.89	Shifting	Neutral	
13	3.12	3.77	0.62	Agree	Neutral	
17	1.99	2.90	0.94	Disagree	Neutral	
23	2.05	3.06	0.95	Shifting	Extreme	
28	2.59	2.15	0.44	Disagree	Extreme	*
Importance and contribution to society						
3	1.54	1.40	0.15	Disagree	Extreme	*
7	4.12	4.39	0.35	Agree	Extreme	
24	3.79	3.74	0.05	Agree	Neutral	
26	2.10	2.33	0.26	Disagree	Neutral	*
29	3.86	4.08	0.25	Agree	Extreme	
Difficulty						
4	2.93	3.27	0.33	Shifting	Extreme	
31	2.98	3.22	0.25	Shifting	Extreme	*
33	2.63	2.52	0.10	Disagree	Extreme	*
Relationship to Math and Science						
6	3.89	4.11	0.25	Agree	Extreme	
11	4.03	4.09	0.07	Agree	Extreme	
16	1.73	1.70	0.02	Disagree	Extreme	*
27	3.73	3.98	0.31	Agree	Extreme	
34	4.10	4.21	0.13	Agree	Extreme	
Gender						
2	1.33	2.10	0.89	Disagree	Neutral	*
8	4.65	4.29	0.45	Agree	Neutral	
21	4.59	4.62	0.04	Agree	Extreme	
32	1.62	2.19	0.49	Disagree	Neutral	*
Connection to Problem Solving						
5	3.94	4.30	0.46	Agree	Extreme	
18	1.94	1.85	0.09	Disagree	Extreme	*
30	3.01	2.98	0.03	Shifting	Extreme	
Problem Solving Capability						
9	3.27	3.45	0.19	Agree	Extreme	
22	3.70	3.84	0.16	Agree	Extreme	
25	2.71	2.56	0.15	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey

.It was apparent that near the end of class, males were still more interested in learning about as well as having a career in engineering and technology. Like the Pre survey results, Post results showed no practically significant difference in perceptions about problem solving confidence. In addition to those found significant by Pre survey responses, importance of contribution to society and connection to problem solving showed practically significant effect sizes for Post responses.

Interest in Career: Related to interest in careers, females showed less interest with effect size of 0.89, 0.94, and 0.95 (mean of the male responses about career interest was greater than approximately 80% of females' responses) for Statements 10, 17, and 23, respectively. The difference in career interest was confirmed by several male students expressing an interest for a technical career in the future during the classroom interviews while the female students did not.

Interest in Learning: Statement 1 with results indicating that females had less interest in technology and engineering (neutral) compared to the male students (strongly disagree). The other five statements in this criterion supported this indication and the interest level difference between male and female students.

Gender: In addition, female students during the Post survey disagreed more strongly than males that "Boys are better at being engineers than girls" (Statement 2) with between strongly disagree and disagree compared to between disagree and neutral for the males. This was similar to what was found in the Pre survey, but now the effect size was only 0.89, ~80%, with both having shifted to more disagreeing. This showed a change in the right direction for women in engineering and technology. The teachers' behavior supported a change in this direction as there were no differences between the assignments that male and female students were assigned and no apparent differences in attitude towards the students based on gender.

Connection to Problem Solving and Relationship to Math and Science: Male students had a more extreme opinion about the connection between problem solving, technology, and engineering than females students in the Post survey. In general, males thought the connection was higher and this was most strongly indicated by survey responses to Statement 5—"Engineers and technologist solve problems." In addition to a connection with problem solving, the stronger connection to math and science explained why males disagreed with Statement 30 "When I think of engineering and technology, I mostly think of problem solving."

Importance and Contribution to Society: Similar to the Pre survey perceptions, males see a greater and more positive importance and contribution of engineering and technology to society. These responses showed a 0.35 effect size with practical significance in the Post perceptions—mean of male responses showing greater perception than nearly 65% of females.

Difficulty: Male students had agreement with two of the three criterion statements on difficulty with extreme opinion about the difficulty of engineering and technology. The female students disagreed with statements about the need to be very smart and take hard classes to be an engineer or technologist. Male students' higher career and learning interests could result from the beliefs that engineering and technology were more prestigious or impressive.

4.3.5 Combined Look at Gender of Student and Teacher Trends

The following two tables show how female students with a female teacher responded to the survey in comparison to male students with a male teacher. Table 4-15 shows the pre survey response differences based on gender and Table 4-16 shows the post survey response differences.

This is included to give insights into if there is a male to female variation when the students are the same gender as the teacher. In both the pre and post survey responses it is apparent that there is a significant difference evidenced by nearly half of the statements in both having effect sizes of at least 0.50—69%.

Table 4-15: Pre-test comparison of female students with a female teacher and male students with a male teacher

S #[1]	Female Mean[2]	Male Mean[2]	Effect Size[3]	Opinion[4]	Differ[5]	
Interest in learning						
1	2.51	1.73	0.74	Disagree	Extreme	*
12	2.88	3.20	0.26	Shifting	Neutral	
14	3.51	4.10	0.54	Agree	Extreme	
15	2.42	2.20	0.20	Disagree	Extreme	*
19	3.22	3.90	0.62	Agree	Extreme	
20	2.51	3.44	0.76	Shifting	Neutral	
Interest in career						
10	2.58	3.60	0.90	Shifting	Extreme	
13	3.34	3.73	0.37	Agree	Extreme	
17	2.06	2.43	0.34	Disagree	Neutral	
23	2.13	2.88	0.67	Disagree	Neutral	
28	2.44	2.00	0.40	Disagree	Extreme	*
Importance and contribution to society						
3	1.43	1.18	0.32	Disagree	Extreme	*
7	3.98	4.27	0.33	Agree	Extreme	
24	3.50	3.75	0.28	Agree	Extreme	
26	1.85	2.38	0.78	Disagree	Neutral	*
29	3.76	3.73	0.05	Agree	Neutral	
Difficulty						
4	3.11	3.45	0.33	Agree	Extreme	*
31	2.84	3.33	0.51	Shifting	Extreme	*
33	2.67	2.18	0.45	Disagree	Extreme	
Relationship to Math and Science						
6	3.75	4.09	0.39	Agree	Extreme	
11	4.18	4.18	0.01	Agree	No Δ	
16	1.83	1.64	0.22	Disagree	Extreme	*
27	3.63	3.50	0.15	Agree	Neutral	
34	4.14	4.09	0.06	Agree	Neutral	
Gender						
2	1.38	2.67	1.64	Disagree	Neutral	*
8	4.78	3.90	1.66	Agree	Neutral	
21	4.76	4.36	0.76	Agree	Neutral	
32	1.39	2.56	1.50	Disagree	Neutral	*
Connection to Problem Solving						
5	3.80	4.36	0.66	Agree	Extreme	
18	1.82	1.50	0.39	Disagree	Extreme	*
30	2.47	3.22	0.80	Shifting	Neutral	
Problem Solving Capability						
9	3.57	3.36	0.24	Agree	Neutral	
22	3.72	3.45	0.32	Agree	Neutral	
25	2.77	3.27	0.47	Shifting	Neutral	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey

When comparing female students with a female teacher to male students with a male teacher, the results from the Pre-survey yielded 14 of the 34 statements with effect sizes above 0.50, four of which were above 0.85. This was one of the most distinctly different comparison groups of the study. All eight measurement criterion showed at least small effect sizes significant differences.

Gender: The three highest were in the gender category—Statements 2, 8 and 32 had effect sizes of 1.64, 1.66, and 1.50, respectively. These are very significant and suggest a mean response by female students with a female teacher that disagreed more strongly that boys are better or have more knowledge than girls at engineering and technology than approximately 95% of male students with a male teacher. It showed females with a female teacher felt more strongly that girls and boys were both fit for engineering and technology than responses by the males with a male teacher. These results showed that the gender of the teacher did largely effect a female student's perception of being fit for engineering and technology. This could have been a result not only of the gender of the teacher, but also the décor of the classroom depicting female engineers as mentioned in the discussion when comparing male and female teachers.

Interest in Career: The next highest effect size relates to career interest—Statement 10. The females' results were between disagreeing and neutral (2.58) while the males' results were between neutral and agree (3.60) that "I would like a job that lets me do a lot of engineering and technology." The female students' trend of less interest was not consistent across all of the statements about career interest. Statements on career interest where both male and female students were not interested the female students had the lowest levels of interest.

Connection to Problem Solving, Importance and Contribution to Society, and Relationship to Math and Science: Male students with a male teacher saw a greater connection between engineering, technology, and problem solving than female students with a female teacher during the first two weeks of t class. Statement 30 responses showed that female students with a female teacher disagreed and male students with a male teacher agreed that "When I think of engineering and technology, I mostly think of solving problems." The female students with a female teacher saw a stronger connection to other things. This suggestion was not confirmed by importance and contribution to society or relationship to math and science. Rather, it was evident that male students with a male teacher also found a stronger connection with math, science, and society.

Interest in Learning: Similar to perception about career interest, male students with a male teacher were more interested in learning about engineering and technology than female students with a female teacher. The disparity in interest was smaller than the disparity when comparing all male students with all female students. Thus it seemed that the gender of the teacher does effect the students' perception of interest.

Problem Solving Capability: Male students with a male teacher found problem solving more difficult, but had more confidence in their ability to solve problems than females with a female teacher.

Difficulty: In addition to finding problem solving more difficult, males with a male teacher also found technology and engineering as requiring more intelligence. This could relate back to the higher interest in learning and career choices due to the opportunity for prestige as mentioned when comparing all male and female students.

Table 4-16: Post-test comparison of female students with a female teacher and male students with a male teacher

S #[1]	Female Mean[2]	Male Mean[2]	Effect Size[3]	Opinion[4]	Differ[5]	
Interest in learning						
1	2.79	1.78	0.93	Disagree	Extreme	*
12	2.73	3.65	0.85	Shifting	Extreme	
14	3.56	4.08	0.55	Agree	Extreme	
15	2.42	2.05	0.40	Disagree	Extreme	*
19	2.95	3.50	0.51	Shifting	Extreme	
20	2.21	3.05	0.67	Shifting	Neutral	
Interest in career						
10	2.29	3.17	0.89	Shifting	Neutral	
13	3.10	3.68	0.53	Agree	Extreme	
17	2.06	2.88	0.75	Disagree	Neutral	
23	1.96	2.95	0.92	Disagree	Neutral	
28	2.80	2.16	0.61	Disagree	Extreme	*
Importance and contribution to society						
3	1.56	1.42	0.15	Disagree	Extreme	*
7	4.00	4.46	0.53	Agree	Extreme	
24	3.68	3.86	0.19	Agree	Extreme	
26	2.06	2.50	0.55	Disagree	Neutral	*
29	3.74	4.09	0.39	Agree	Extreme	
Difficulty						
4	2.76	3.29	0.51	Shifting	Extreme	*
31	2.98	3.29	0.31	Shifting	Extreme	*
33	2.61	2.55	0.06	Disagree	Extreme	
Relationship to Math and Science						
6	3.78	4.22	0.47	Agree	Extreme	
11	4.06	4.09	0.04	Agree	Extreme	
16	1.62	1.68	0.08	Disagree	Neutral	*
27	3.84	4.10	0.31	Agree	Extreme	
34	4.03	4.18	0.17	Agree	Extreme	
Gender						
2	1.24	2.30	1.50	Disagree	Neutral	*
8	4.66	4.35	0.41	Agree	Neutral	
21	4.63	4.70	0.08	Agree	Extreme	
32	1.54	2.19	0.63	Disagree	Neutral	*
Connection to Problem Solving						
5	3.77	4.55	0.98	Agree	Extreme	
18	2.06	2.05	0.01	Disagree	Extreme	*
30	2.78	2.86	0.08	Disagree	Neutral	
Problem Solving Capability						
9	3.41	3.45	0.05	Agree	Extreme	
22	3.66	3.83	0.19	Agree	Extreme	
25	2.61	2.55	0.07	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey

. The results from the Post survey yielded 16 of 34 statements with effect sizes above 0.50; of which six were above 0.85. The Post data showed greater effect size significance over the Pre survey data. All measurement criteria except problem solving capability showed at least small effect sizes of significance.

Gender: The difference in perception of engineering and technology being appropriate for both females about males decreased (effect size range 0.08 to 1.50, ~0 to 93%, rather than 0.76 to 1.66, ~77 to 95%). This showed a drastic change on the part of the male students with a male teacher, because the female students with a female teacher became more extreme in perception of appropriateness for both genders.

Interest in Career: The career interest difference increased drastically. In some cases, this was due to a decrease in interest by females and in other cases an increase in interest by the male students. This drastic difference was confirmed by the class visits when comparing students only with the same gender as their teacher similar to the discussion when comparing students based on their gender only.

Interest in Learning: Learning interest also showed a clear trend with large effect sizes. In all cases male students were more interested in learning about engineering and or technology. Even with this higher interest from males, it was clear when comparing the student comments that female students with a female teacher were more inclined to take another technology and engineering class than female peers with a male teacher.

Connection to Problem Solving, Importance and Contribution to Society, and Relationship to Math and Science: Again male students with male teacher saw a greater connection to problem solving, society, math, and science. There was not a clear trend when comparing effect sizes Pre to Post, but was clear that the general difference in erception was maintained during the last two weeks of the course.

Difficulty: The disparity in perception of difficulty went up after having taken the course—female student with a female teacher disagreed with Statements 4 and 31, while male students with a male teacher agreed that one would have to be smart and take hard classes to be an engineer or technologist. This again may give insights into interest disparity.

Additional Insights: These changes in combination suggest that the greater gender equality of appropriateness perceived by female students did not lead the female student's initial interest in learning or career pursuit to increase.

The following two tables (Table 4-17 and 4-18) show how female students with a male teacher responded to the survey when compared to male students with a female teacher.

Table 4-17: Pre-test comparison of female students with a male teacher and male students with a female teacher

S #[1]	Female Mean[2]	Male Mean[2]	Effect Size[3]	Opinion[4]	Differ[5]	
Interest in learning						
1	2.71	2.31	0.38	Disagree	Extreme	*
12	2.41	3.36	0.98	Shifting	Neutral	
14	3.74	3.85	0.11	Agree	Extreme	
15	3.25	2.18	1.03	Shifting	Neutral	*
19	3.50	3.86	0.40	Agree	Extreme	
20	2.32	3.10	0.67	Shifting	Neutral	
Interest in career						
10	2.5	3.38	0.9	Shifting	Neutral	
13	3.55	3.78	0.25	Agree	Extreme	
17	1.94	2.62	0.8	Disagree	Neutral	
23	2.16	2.75	0.59	Disagree	Neutral	
28	2.58	2.19	0.39	Disagree	Extreme	*
Importance and contribution to society						
3	1.29	1.43	0.15	Disagree	Neutral	*
7	4.11	4.00	0.13	Agree	Neutral	
24	3.85	3.72	0.15	Agree	Neutral	
26	2.44	1.97	0.50	Disagree	Extreme	*
29	4.15	3.90	0.30	Agree	Neutral	
Difficulty						
4	2.73	3.74	0.96	Shifting	Extreme	
31	2.53	3.65	1.10	Shifting	Extreme	*
33	3.06	2.59	0.37	Shifting	Extreme	*
Relationship to Math and Science						
6	4.00	4.27	0.37	Agree	Extreme	
11	4.06	4.32	0.34	Agree	Extreme	
16	1.95	1.59	0.35	Disagree	Extreme	*
27	3.74	3.85	0.11	Agree	Extreme	
34	4.10	4.33	0.27	Agree	Extreme	
Gender						
2	1.83	2.39	0.53	Disagree	Neutral	*
8	4.83	4.29	0.68	Agree	Neutral	
21	4.95	4.50	0.69	Agree	Neutral	
32	1.42	1.80	0.41	Disagree	Neutral	*
Connection to Problem Solving						
5	4.43	4.00	0.59	Agree	Neutral	
18	1.60	1.97	0.36	Disagree	Neutral	*
30	3.05	2.75	0.29	Shifting	Extreme	
Problem Solving Capability						
9	3.00	3.54	0.53	Agree	Extreme	
22	3.75	3.83	0.08	Agree	Extreme	
25	2.89	2.66	0.22	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey

Pre test comparisons resulted in four effect sizes above 0.90 and 14 of the 34 criterion statements above 0.50. This was similar to the magnitude and amount of difference when comparing responses of female students with a female teacher to male students with a male teacher. All measurement criteria showed at least small effect sizes.

Interest in Learning: There were two effect sizes of significance related to interest in learning and taking another class and two others related to the difficulty of engineering and technology. For the category of interest in learning, Statements 12 and 15 had effect sizes of 0.97 and 1.03, respectively and in the range of 85% based on Cohen's percentages. For both of these questions the male and female students were on opposite sides of neutral. The trend of different sides of neutral was true for Statement 12 comparing female students with a female teacher survey data and male students with a male teacher, but was not the case for Statement 15. Statement 15 gave insight into how having a teacher of different gender effected the students. Females with a male teacher agreed with "I would be nervous to take a technology and engineering class," while females with a female teacher disagreed during the first two weeks of the class experience.

Difficulty: The two statements in the category of "difficulty" of engineering and technology where the females and males were on opposite sides of neutral were 4 and 31 with effect sizes of 0.96 and 1.10, respectively again a difference in the range of about 85% of the respondents. Males felt that a person had to be smarter and take harder classes than females.

Interest in Career: While in general it does not seem that male students with a female teacher or female students with a male teacher were very interested in a career in engineering or technology, the male students were more interested. In addition, the disparity in interest was greater than when comparing all male students to all female students. The data gives insight to the research question: “Do female teachers have a stronger effect on female students’ perception and attitude towards engineering and technology than male colleagues based on the categories that the survey investigates?”

Gender: Similar to the comparison of students with the same gender as their teacher, female students with a male teacher more strongly perceived that both males and females were fit for engineering and technology, but the disparity was much smaller. The effect size range was 0.41 -0.69, 66-76%, rather than 0.76-1.66 ,78-95%.

Connection to Problem Solving, Importance and Contribution to Society, and Relationship to Math and Science: Once again, male students saw a greater connection of problem solving, society, math, and science with technology and engineering. There was not a clear trend when comparing students with the same gender as the teacher, but added to the evidence that the interest disparity was related to the perceptions of connection of engineering and technology with other topics.

Problem Solving Capability: The male students with a female teacher had a higher confidence in problem solving than female students with a male teacher during the first two weeks of class. One statement in this criterion had a significant effect size (0.58, ~70%).

Table 4-18: Post-test comparison of female students with a male teacher and male students with a female teacher

S #[1]	Female Mean[2]	Male Mean[2]	Effect Size[3]	Opinion[4]	Differ[5]	
Interest in learning						
1	2.87	2.03	0.69	Disagree	Extreme	*
12	3.14	3.43	0.26	Agree	Extreme	
14	3.95	3.87	0.09	Agree	Neutral	
15	2.95	2.42	0.46	Disagree	Neutral	*
19	3.13	3.76	0.61	Agree	Extreme	
20	2.41	3.05	0.55	Shifting	Neutral	
Interest in career						
10	2.50	3.36	0.82	Shifting	Neutral	
13	3.15	3.82	0.65	Agree	Extreme	
17	1.88	2.91	1.22	Disagree	Neutral	
23	2.17	3.13	0.91	Shifting	Neutral	
28	2.27	2.14	0.14	Disagree	Extreme	*
Importance and contribution to society						
3	1.51	1.38	0.14	Disagree	Extreme	*
7	4.27	4.34	0.10	Agree	Extreme	
24	3.96	3.66	0.32	Agree	Neutral	
26	2.14	2.24	0.10	Disagree	Neutral	*
29	4.03	4.08	0.06	Agree	Extreme	
Difficulty						
4	3.14	3.25	0.11	Agree	Extreme	
31	2.97	3.18	0.21	Shifting	Extreme	*
33	2.65	2.50	0.13	Disagree	Extreme	*
Relationship to Math and Science						
6	4.05	4.05	0.00	Agree	No Δ	
11	4.00	4.09	0.10	Agree	Extreme	
16	1.89	1.71	0.16	Disagree	Extreme	*
27	3.57	3.92	0.41	Agree	Extreme	
34	4.21	4.23	0.02	Agree	Extreme	
Gender						
2	1.45	1.97	0.52	Disagree	Neutral	*
8	4.63	4.26	0.45	Agree	Neutral	
21	4.54	4.58	0.05	Agree	Extreme	
32	1.75	2.18	0.34	Disagree	Neutral	*
Connection to Problem Solving						
5	4.17	4.16	0.01	Agree	Neutral	
18	1.78	1.74	0.05	Disagree	Neutral	*
30	3.33	3.05	0.27	Disagree	Neutral	
Problem Solving Capability						
9	3.09	3.45	0.34	Agree	Extreme	
22	3.76	3.84	0.09	Agree	Extreme	
25	2.85	2.58	0.31	Disagree	Extreme	*

[1]S# is the statement number on the survey. (Table 4-1).
[2] Responses of "I do not know" were excluded from the analysis, and 1-5 ranges with strongly disagree =1, neutral =3, and strongly agree =5
[3]Effect sizes are given as the absolute value.
[4]The overall opinion in response to the criteria statement. Shifting denotes change in opinion from Pre to Post surveys.
[5]Opinion in column three compared with column two—were the responses in column three more extreme or more neutral that the responses in column two.
* Negatively stated criteria in survey.

Post survey responses comparisons resulted in all measurement criteria with at least small effect sizes except difficulty and connection to problem solving.

Interest in Career: Post test comparisons were different than the Pre-test comparisons with only two effect sizes being above 0.90. Both were in the category of career interest shown in Statements 17 and 23. On average males showed a higher degree of interest in being both an engineer and technologist than nearly 85% of females. Evidence toward an understanding of a potential gender of student difference rather than a combined effect of gender of student and gender of teacher was given.

In addition, effect sizes of both males and females showed greater interest in being engineers (Males 3.13and females 2.17) than in being technologists (Males 2.19 and females 1.88). It was interesting that interest in being engineers between male and female students is the same as the male student's interest difference between being engineers and technologists. In other words, the difference between the female and male students perception could be associated with social acceptance of the roles as can be seen from the comparable difference when compare to similar careers that have different social connotations.

Learning Interest: Similar to career interest, males with a female teacher had a higher interest in learning about engineering and technology than females with a male teacher. The difference in learning interest was generally less extreme than the difference between females with a female teacher and males with a male teacher (effect sizes in the range of 0.09 - 0.69, 54-76%, rather than 0.40 - 0.93, 66-81%). This was because females with a male teacher were more interested than females with a female teacher and males with a female teacher were less interested than males with a female teacher

Gender: The disparity in opinion decreased in comparison with the Pre survey responses about perception of both females and males being fit for engineering—the male students with a female teacher and female students with a male teacher had a more similar opinion after having taken the course than before.

Relationship to Math and Science: Statement 27 responses showed a small effect size of 0.41 and all other statements confirmed the greater perception of a connection of engineering and technology with math and science by male students with a female teacher than female students with a male teacher.

Problem Solving Capability: The mean of the responses of male students with a female teacher showed the male students felt that problem solving was easier (0.31, ~62% Statement 25) and were more confident in their ability to solve problems (0.34, ~63% Statement 9) than more than 60% of female students with a male teacher. The similarity in the magnitude of this difference could suggest that the difference in perceived ability is connected to the difference in perceived difficulty.

Importance and Contribution to Society: On average females with a male teacher thought that engineers and technologist jobs were more influenced by 'societal issues, like water and air pollution' than nearly 65% of male students with a female teacher (0.32, Statement 24). This trend was opposite of the trend when comparing all students with a female teacher to all students with a male teacher and much stronger than when comparing all female students to all male students. This suggested that is a strong trend based on the combined effect of gender of the student and teacher rather than the gender of the student or teacher alone.

5 Implications, Conclusions and Recommendations

This chapter is broken into three main sections. In the first section, there is a brief overview of the general conclusions to the research questions. A more detailed look at the conclusions related to each research question is discussed by measurement criteria in the second section. The final section includes a closing summary about the research.

5.1 Overview of Conclusions for Research Questions

- Do female teachers have a stronger effect on female students' perception and attitude towards engineering and technology than male colleagues?
    - Female students with a female teacher had a higher perception of both females and males being fit for engineering and technology than the female peers with male teachers or any of their male peers.
- Do male students have greater interest towards engineering and technology than female peers?
    - On average male students showed a higher learning interest as well as career interest both pre (effect sizes 0.30 to 0.80) and post (effect sizes 0.26 to 0.95) than 62-83% of female students.
    - This disparity was greater during the post survey than pre.

- Are students interested in learning about or having a career in engineering and technology with science, math, society, and/or problem solving?
    - The students perceived these connections as evidenced in both the pre and post assessments. The perceived connection to problem solving was less than the perceived connection to science, math, and society.
- Are students interested in learning about or having a career in engineering and technology?
    - Students were generally interested in learning about engineering and technology. There was less interest in having a career in engineering and technology.
- Do students perceive engineering and technology as difficult curriculums?
    - The students perceived that engineering and technology required one to be 'smart.' Male students thought so more strongly than female students.

5.2 Theoretical and Practical Implications

This research has both theoretical and practical implications, they are related to: 1) learning and career interest, 2) importance and contribution to society, 3) multidisciplinary relationships, 4) gender equality, 5) problem solving connection, 6) problem solving confidence, and 7) engineering and technology difficulty. Each will be discussed in turn.

5.2.1 Learning and Career Interest

The research findings support and build upon the theoretical framework suggested by the Bame et al studies on student technological interest, and Lee's research regarding the effect of learning experiences on student perception (Bame, 1993 and Lee, 2002). The criteria area for learning and career interest research conclusions suggest:

1. Females do have interest in technology related areas, but usually do not recognize it.
2. Females need to take technology related classes to develop understanding and desire for engineering and technology skills.
3. Technology and engineering classes need to incorporate more activities that cultivate student interest in these fields.
4. Male students are more interested in engineering and technology, but this higher interest could be connected with other disparities in perception between female and male students.

Males showed higher learning and career interest by agreeing more strongly than females with all of the interest in learning statements. Females' interest increased similarly over the term of classroom instruction with effect sizes in the range of 0.01 to 0.26 for female students compared to the values of 0.09 to 0.25 for the males. The limited commitment of females to qualitative answers about interest in learning and career (simple shaking of head, or hesitant "uh huh") with an increase in interest after taking the class, showed females students seemed to be more open to learn and explore new and innovative technology related areas. These findings were supported by Magleby (2008) and support Wulf's conclusion that engineering and technology classes were essential because they provide both girls and boys the opportunity to learn and be exposed to areas in which they may have interest (Wulf, 2002). It also supported the idea that females were less interested in technology (Raat and deVries, 1985, Boser, Palmer, and Daughtery, 1998, Frantom, Green, and Hoffman, 2002, and Bame and Dugger, 1993).

During the class visits the students gave positive responses about the engineering and technology experiences. This suggested the teachers were doing a good job of incorporating engineering into the technology classes without eliminating the value of the class to those students who do not want to be an engineer as Gorham predicted (Gorham, 2002).

The questions relating to *interest perception* showed two things: 1) male students had higher career and learning interests in engineering and technology fields because they believed these fields to be prestigious and impressive. 2) Male students perceived technology and engineering had a great connection with societal issues than females.

5.2.2 Importance of Contributions to Society

The main conclusion regarding the importance of *contributions to society* showed:

1. The student's belief regarding the perception of the importance technology and engineering contribute to society increased over the course of classroom instruction for both males and females.
2. There was not a consistent perception of the contributions being positive or negative, but rather a feeling that the contributions were "good in ways and bad in ways."

An increased awareness of negative consequences that engineering and technology can bring about and contributions engineering and technology provide to make life better and more comfortable could have affected perception in this criterion. One student's comment "[engineering and technology] is probably good in ways and bad in ways" is representative of the general student sentiment regarding the importance of technology and engineering to society.

This perspective by students was a realistic perception as technology and engineering have the capacity to make societal strides, such as the internet, which have both positive and negative implications. Thus suggesting an increase in the technical literacy needed to make educated decisions, which agrees with Carulla's suggested need (Carulla, 2007). It also supports the need for technologists and engineers to be responsible to ensure that implications are thoroughly understood (Wulf, 2002).

Based on this, as a teacher, it might be productive to 1) include ethics of engineering and technology in the curriculum since the evidence, in agreement with Gorham, suggested that students were trying to understand if the contributions were good or bad and will be making several personal and community decisions about technologies (Gorham 2002). In addition, 2) highlighting applications and creativity in engineering and technology with the simple mechanical knowledge adds multidisciplinary advantages (Thom, 2001). The development of multidisciplinary advantages will enable more opportunities of future developmental trends for diversity involvement with a traditionally male field of technology and engineering.

5.2.3 Multidisciplinary Relationships

The data regarding multidisciplinary relationships shows/suggests/verifies/etc:

1. Students overall did not show a change in perception of the connection of engineering and technology with math and science from Pre to Post survey responses.

2. Students initially agreed on the connections with math and science.

3. Examining the class-by-class data, there appeared to be slight increase from Pre to Post in the connection to science and a slight decrease in the connection to mathematics.

Since the notion of problem solving in technology and engineering involves the idea of analysis, the slight decrease in the connection with mathematics suggested the students realized during the class projects that other analysis skills besides mathematics were necessary to develop the projects. It was suggested that comparing the learning tools and techniques used during the engineering projects in the classroom could provide insight into how the classroom engineering projects match with the engineering design process and thus problem solving (Merrill, 2006). This may support the changes in perception in comparison of Pre survey to Post survey data.

5.2.4 Gender Equality

The study found that:

1. Female students had a greater perception that engineering and technology were for both boys and girls than the male students.

2. Females with a female teacher felt more strongly that girls and boys were fit for engineering and technology.
3. The perception of equal gender appropriateness of engineering and technology was not evident in female student perceptions of interest data.
4. Female students with a female teacher perceived higher equal gender appropriateness than female students with a male teacher.
5. Overall, class experiences resulted in varying perception influences on female students.
6. During the pre survey, mean responses by female students with a female teacher disagreed more strongly that boys are better or have more knowledge than girls at engineering and technology than approximately 95% of male students with a male teacher.

Results showed that the gender of the teacher influences students' perception of gender appropriateness. It also confirmed results from other studies on female students' perception of engineering and technology being appropriate for both females and males (Boser, Palmer, and Daughtery, 1998, and Bame and Dugger, 1993).

The increase in perception of appropriateness was not accompanied by an increase in learning or career interest. This was not promising as seventh grade was an ideal time to influence interest with less gender stereotype barriers (Cummings and Taebel, 1980).

Female students with a female teacher had more positive perceptions of gender equality. The positive perception supported the need to increase female role models in engineering and technology with more involvement by female teachers in engineering and technology (Gibson, 2004).

In short, the research findings suggested that the influence of an engineering and technology class on a female's perception varied. The variability may be due to different teaching techniques and/or projects used by the different teachers. The influence of engineering and technology classes on female perceptions should be an area of further investigation (Boser, Palmer, and Daughtery, 1998).

One recommendation for future studies of gender perceptions is to include statements with opposing wordings such as the following. Boys are better than girls at engineering and technology. Girls are smarter and engineering and technology than boys.

5.2.5 Problem Solving Connection

The conclusions for the *connection of problem solving* to technology and engineering included:

1. Male students saw a greater connection of problem solving to technology and engineering.
2. There was not a pre to post survey response change in perception of the connection of engineering and technology to problem solving.
3. The exceptions were Class 4 (students with a male teacher) showed a decrease in connection, and Class 3 (students with a female teacher) female students showed an increased connection. The students during the class visits could describe classroom experiences wherein problem solving strategies had been used but the overall perception was neither to agree nor disagree that engineering and technology were connected to problem solving. The class

curriculums required the students to solve problem ranging from trouble shooting the performance of the cars on a track to answering questions about the environmental impact of plastics, but the survey showed that the students did not make a direct connection to problem solving.

5.2.6 Problem Solving Confidence

The survey showed that:

1. Female students were slightly less confident in problem solving than male students.
2. The classroom experiences resulted in varied perception of problem solving confidence.

During class visits, male students were less likely to work together or ask the teacher for help in problem solving. This may suggest that while the female students may be less confident in problem solving, they are more willing to get help when needed. There was no evidence found that suggested any gender as less capable of solving problems.

During the class visits students of both genders were able to describe times when the students had solved problems during the class. This suggested an explanation to studies which have found student confidence in solving problems was higher if involved with a pre-engineering class (Hirsch, Carpinelli, Kimmel, Rockland, and Bloom, 2007). The influence on confidence varied between classes as can be seen when comparing effect sizes for Classes 1 and 3 with Classes 2 and 4 (first pair consistently higher than second).

5.2.7 Engineering and Technology Difficulty

The main conclusions in the *level of difficulty* measure are:

1. Male students perceived engineering and technology as more difficult than female students.
2. Different classroom experiences resulted in different perceptions supporting Boser, Palmer, and Daughtery (1998).

The higher perception of difficulty by male student suggested that the previous gender capability studies were at least accurate about personal perceptions of capability—females and males have engineering and technology ability (Committee on Maximizing the Potential of Women in Academic Science and Engineering; Committee on Science, Engineering, and Public Policy, 2007).

In one of the female teacher's classes, students felt that engineering and technology were less difficult after having taken the class, in contrast to one of the male teacher's classes where students felt the topics were more difficult.

It is recommended that teachers perform an assessment of activities to determine if there might be a connection between the activity and the perception of the students regarding the difficulty of engineering and technology. The use of such an instrument to gauge perception of difficulty could give a teacher the opportunity to determine what classroom experiences facilitate student confidence in engineering and technology.

5.3 Closing Summary

In conclusion, student concept and interest in engineering and technology was affected by taking a class in engineering and technology during middle school. The recognized affect on students provides teachers and curriculum planners with the awareness that the classroom experience effect more than content knowledge about technology and engineering. In addition, the students' willingness to change perceptions gave both teachers and curriculum planners increased understanding of the impacts of this influence. It also showed that including engineering in the curriculum is critical, because the perceptions about engineering were affected by the classroom experiences. The *Technology and Engineering Attitude Scale (TEAS)* survey instrument created along with theoretical and practical implications of the study provided tools to gauge influence and tailor implementations towards positive changes in perception for engineering and technology.

6 References

Bates, P. D., Stewart, M. D., Desitter, A., Anderson, M. G., Renaud, J. P., and Smith, J. A. (2000). "Numerical simulation of floodplain hydrology." *Water Resources Research*, 36(9), 2517-2529.

Bennett, C. A. 1926. *History of Manual and Industrial Education up to 1870.* Peoria, IL: Manual Arts.

Bennett, C. A. 1937. *History of Manual and Industrial Education 1870 to 1917.* Peoria, IL: Manual Arts.

Blaisdell, S. 2000. Students' decisions to enter EngineeringL how men and women differ. In *WEPAN 2000 national conference.*.

Boser, R., Palmer, J., and Daughtery, M..1998. Students Attitude Toward Technology in Selected Technology Education Programs. *Journal of Technology Education* 10, no. 1 (Fall): 4.

Braun, D., Evans, E., Knight, R., and Ruehr, M. 2007. Interdisciplinary team teaching lessons for engineering instructors from a capstone course in environmental studies. In *2007 ASEE annual Conference*.

Burger, C. 2007. Female student views about IT careers in high school and college. In *2007 ASEE annual Conference*.

Carulla, C., Duque, M., Molano, A., and Henandez, J. 2007. Trends in Pre-College Engineering and Technology Education and the Pequenos Cientificos Program. *The International Journal of Engineering Education* 23, no. 1: 9.

Committee on Maximizing the Potential of Women in Academic Science and Engineering, and Comittee on Science, Engineering, and Public Policy. 2007. *Beyond bias and barriers--fulfilling the potential of women in academic science and engineering.* Washington, DC: The National Academies Press.

Committee on Technical Literacy. 2002. *Technically speaking: Why all Americans need to know more about technology.* Washington, DC: National Academies Press.

Conrad, L., Conrad, E., and Auerbach, J. 2007. The development, implementation and assessment of an engineering research experience for physics teachers. In *2007 ASEE annual Conference*.

Cummings, S., Taebel, D. 1980. Sexual Inequality and Reproduction of Consciousness: An Analysis of Sex-Role Stereotyping Among Children. *Sex Roles* 6, no. 4 (August).

De Vries, M. 1997. Teaching Technology for Entrepreneurship and Employment: An International 'PATT" Conference. *The Technology Teacher* (April).

Europe, history of "The Renaissance—Renaissance science and technology". 2009.Encyclopedia Britannica online Academic Edition http://search.eb.com/eb/article-58232, Internet, accessed 6 February 2009.

Frantom, C., Green, K., and Hoffman, E. 2002. Measure Development: The Children's Attitude Toward Technology Scale (CATS)*. *Journal of Educational Computing Researching* 26, no. 3: 249.

Gallaher, J., and Pearson, F. 2000. Women's Perceptions of the Climate in Engineering Technology Programs. *Journal of Engineering Education* (July).

Gibbons, M. 2006. *Engineering by the Numbers.* American Society for Engineering Education.

Gibson, D. 2004. Role Models in Career development: New directions for theory and research. *Journal of Vocational Behavior* 65: 134.

Gorham, D. 2002. Engineering and Standards for Technological Literacy. *The Technology Teacher* 61, no. 7 (April) : 29.

Hilger, H., et al. 2007. Multi-campus design and implementation of problem-based learning courses in environmental biotechnology with interdisciplinary learning. In *2007 ASEE annual Conference*.

Hirsch, L., Carpinelli, J., Kimmer, H., Rockland, H., and Bloom, J. 2007. The differential effects of women only vs co-ed enrichment programs on middle school students' attitude to science, mathematics, and engineering. In *2007 ASEE annual conference*.

International Technology Education Association. 2000. Standards for technological literacy: Content for the study of technology. National Science Foundation under Grant No. ESI-9626809 and the National Aeronautics and Space Administration under Grant No. NCC5-172.

Jeffery, T. 1993. Adaptation and validation of a technology attitude scale for use by american teachers at the middle school level. Ph.D. diss., Virginia Polytechnic Institute and State University.

Kniveton, B.H.. 2004. The influences and motivations on which students base their choice of career. *Research in Education* (72) : 47.

Kuh, G. 2000. National Survey of Student Engagement: The College Student Report.

Lee, J. 2002. More Than Ability: Gender and Personal Relationships Influence Science and Technology Involvement. *Sociology of Education* 75, no. 4 (October) .

Lewis, T. 2005. Coming to Terms with Engineering Design Content. *Journal of Technology Education* 16, no. 2 (Spring) .

Lewis, T. 1999. Research in Technology Education-- Some Areas of Need. *Journal of Technology Education* 10, no. 2 (Spring) .

Loftus, M. 2007. Why Won't She LISTEN? *ASEE PRISM* (Dec 2007) : 26.

Lopez, F. and Ann-Yi, S. 2006. Predictors of Career Indecision in Three Racial/Ethnic Groups of College Women. *Journal of Career Development* 33: 29.

Mariga, J., Harriager, A. 2007. A multi-pronged approach to address the IT gender gap. In *2007 ASEE annual conference*.

Massachusetts Department of Elementary and Secondary Education, Massachusetts Curriculum Framework Site, 12 November 2008, available from http://www.doe.mass.edu/frameworks/current.html; Internet, accessed 6 February 2009.

Merrill, C., Childress, V., Custer, R., and Rhodes, C. 2006. Infusing engineering concepts into technology education. In *2006 american society of engineering education annual conference*.

Merrill, C., Custer, R., Daughtery,J. Westrick, M., and Zeng, Y. 2007. *Delivering Core Engineering Concepts To Secondary Level Students.*

Mississippi Department of Education, 10 June 2002, available from: (http://www.mde.k12.ms.us/ovte/instdev/TEwebpage.html, Internet, accessed 6 February 2009.

Mulberg, C. 1993. 'Just Don't Ask Me to Define It': Perceptions of Technology in the National Cirriculum. *Journal of Design History* 6, no. 4: 301.

National Center for Engineering and Technology. National Science Foundation Grant No ESI-0426421.

Orabi, Il. 2007. Gender differences in student academic performance and attitude. In *2007 ASEE annual COnference*.

Pearson, G. 2004. Collaboration Conundrum. *Journal of Technology Education* 15, no. 2 (Spring) .

Pierce, R., Stacey, K., and Barkatsas, A. 2007. A Scale for Monitoring Students' Attitude to Learning Mathematics with Technology. *Computers and Education* 28: 285.

Pirrie, A., Hamilton, S., and Wilson, V. 1999. Multidisciplinary Education: Some Issues and Concerns. *Educational Research* 41, no. 3 (Winter) : 301.

Prakken, L.. 1976. Industrial education in America: A capsule history--1776 to 1976. In Edited by Anonymous Prakken Publications.

Raat, J. De Vries, M. 1985. What do 13-year old students think about technology? The conception of and the attitude towards technology of 13-year old girls and boys. *Eindhoven Univeristy of Technology, The Netherlands* .

Ritz, J. 2006. Technology and Engineering Are Both Addressed Through Technology Education. (Cover story). *Technology Teacher* 66, no. 3; 3 (11) : 19-21.

Rogers, S., Rogers, G. 2005. Technology Education Benefits from the Inclusion of Pre-engineering Education. *Journal of Industrial Teacher Education* 42, no. 3: 88.

Sadler, P., Coyle, H. and Schwartz, M. 2000. Engineering Competitions in Middle School Classrooms: Key Elements in Developing Effective Design Challenges. *Journal of Learning Sciences.*

Siller, T., De Miranda, M., and Whaley, D.. 2007. Engineering Education Partnership. *The International Journal of Engineering Education* 23, no. 1: 58.

Stwalley, C. 2007. The effects of gender on elementary-aged student's interest in technology: A preliminary report. In *2007 ASEE annual conference*.

Tennessee Department of Education, Career and Technical Education site, 6 February 2009, available from: http://www.tennessee.gov/education/cte/te/; Internet, accessed *of the national science teachers association*.

Thom, M. 2001. Young Women's Progress in Science and Technology Studies: Overcoming Remaining Barriers. *National Association of Secondary School Principals Bulletin* 85, no. 6.

Williams, D., Qualitative Book Appendix H site, unknown update date available from http://webpub.byu.net/ddw/qualitativebook/append_h.html; Internet, accessed 6 February 2009.

United States Department of Education, Elementary and Secondary Education Site, 15 September 2004, available http://www.ed.gov/policy/elsec/leg/esea02/index.html; Internet, accessed 6 February 2009.

Utah State Office of Education, Area of Studies site, 7 October 2008, available form: http://www.schools.utah.gov/cte/tech.html, Internet, accessed 6 February 2009.

Warren, C. 1990. An exploration of factors influencing the career preferences of junior high students. In *Annual meeting* 6 February 2009.

Wilson, B., Harvey, T. 1985. Gender Differences in Attitudes Towards Microcomputers Shown by Primary and Secondary School Pupils. *British Journal of Educational Technology* 16, no. 3 (October) .

Wulf, W. 2002. The urgency of engineering education reform. In The laboratory for innovative engineering education 2002 distinguished lecture.

APPENDICES

Appendix A: TEAS Instrument

Survey: Technology and Engineering Attitude Scale

Today's Date: ________________

Gender: Female Male

There are 34 statements about engineering and technology on the next few pages. Some of them you may agree with and others you may not. Please put an X in the box that most describes what YOU think about the statement.

For example:
If you strongly agree with the statement, you will put an X in the box below "Strongly Agree," which has a 5 in it.
If you can't decide if you agree or disagree, you will put an X in the box below "Neutral," which has a 3 in it.
If you don't understand the statement or if you don't think you know enough the statement to answer, you will put an X in the box below "I don't know," which has a 0 in it.

After completing these 34, feel free to share anything else YOU think about engineering and technology.

		I don't know	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I am not interested in technology and engineering.	0	1	2	3	4	5
2	Boys are better at being engineers than girls.	0	1	2	3	4	5
3	Engineering and technology have nothing to do with our lives.	0	1	2	3	4	5
4	To be good at engineering or technology you have to be very smart.	0	1	2	3	4	5
5	Engineers and technologist solve problems.	0	1	2	3	4	5
6	I think engineering and technology are often used in science.	0	1	2	3	4	5
7	Engineers and technologists help make people's lives better.	0	1	2	3	4	5
8	Girls can be as successful doing engineering and technology as boys.	0	1	2	3	4	5
9	I am good at problems that can be solved in many different ways.	0	1	2	3	4	5
10	I would like a job that lets me do a lot of engineering and technology.	0	1	2	3	4	5
11	Engineers and technologist use a lot of math and science.	0	1	2	3	4	5

		I don't know	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
12	I think I could do well in an advanced technology and engineering class.	0	1	2	3	4	5
13	I think that having a job in engineering or technology would be fun.	0	1	2	3	4	5
14	I think there should be a class at my school related to technology and engineering.	0	1	2	3	4	5
15	I would be nervous to take a technology and engineering class.	0	1	2	3	4	5
16	Science has nothing in common with technology and engineering.	0	1	2	3	4	5
17	I would like to be a technologist when I grow up.	0	1	2	3	4	5
18	You do not have to problem solve to be an engineer or technologist.	0	1	2	3	4	5
19	I would like to learn more about technology and engineering at school.	0	1	2	3	4	5
20	If there was a technology and engineering club at my school, I would like to join.	0	1	2	3	4	5
21	A girl can have a technical job.	0	1	2	3	4	5
22	In my everyday life, I am able to solve problems well.	0	1	2	3	4	5
23	I would like to be an engineer when I grow up.	0	1	2	3	4	5

		I don't know	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
24	Societal issues, like water and air pollution, influence the jobs of technologists and engineers.	0	1	2	3	4	5
25	Solving problems is hard.	0	1	2	3	4	5
26	Technology and engineering has brought about more bad things than good things.	0	1	2	3	4	5
27	To me, the field of science is related to the field of technology and engineering.	0	1	2	3	4	5
28	Working in engineering and technology as a job would be boring and dull.	0	1	2	3	4	5
29	Engineering and technology make our lives more comfortable.	0	1	2	3	4	5
30	When I think of engineering and technology, I mostly think of solving problems.	0	1	2	3	4	5
31	To become an engineer or technologist, you have to take hard classes.	0	1	2	3	4	5
32	Boys know more about engineering and technology than girls.	0	1	2	3	4	5
33	You don't have to be smart to study engineering and technology.	0	1	2	3	4	5
34	In engineering and technology, you use math.	0	1	2	3	4	5

Appendix B: TEAS Teacher Instructions

The following is one example of the instructions to the teacher personalized to previous correspondence:
"Since this is still in the first 15%ish of the class, I think the comparison will still be strong. I am excited that this will give us an opportunity to survey more than one block of your class. Thank you!

For protocol purposes, we need to use the copy of the informed consent that has been stamped with approval. I will not be able to get that scanned in until I get home. Would it be too late for you to get copies for your class tomorrow if I email it to you that by 6pm tonight? I work well with due dates like you. Parents are likely similar, so on the informed consent, I have a blank at the end of the 5th paragraph for you to write in the date it needs to be returned that best fits with your schedule.

I want to make this as convenient for you as possible. I apologize that I did not have a chance to get hard copies of forms and surveys to you. Talking with other teachers and comparing the length with previously given surveys, it has been estimated that it will likely take the students about 20 minutes to complete. Please, let me know if that estimate and comparison was accurate. I am hoping this will go smoothly for you and your class without too much inconvenience for anyone, such that we can do this same with your next block of the class."

Appendix C: Letter of Informed Consent

Informed Consent Form
An Education Survey in Technology and Engineering

Dear Parents:

As partial requirements for my graduate degree, I (Kari Cook) along with Dr. Steven Shumway and Dr. Ron Terry will be conducting a study this fall and spring with middle schools in the Alpine, Wasatch, and Jordan School Districts. As part of the study, students will be asked to voluntarily participate in a survey about technology and engineering. The technology education class of which your student is a member has been selected as a possible class to participate in this study. The code of ethics for research requires that participants and their parents/guardians be informed of the purpose of the study and any benefits or potential risks that participating in the study might incur.

The purpose of this study is to investigate affects of gender of teacher, gender of student, and their technology class on the students' concept of and attitude towards technology and engineering. The benefit of this study is that any information learned will be shared to improve technology and engineering classes.

As with educational surveys, this survey has a few potential risks which parents should be informed of. The 7th grade students will be responding to their agreement with statements about technology and engineering. There may be discomfort if the student is unfamiliar with the specific aspect of technology or engineering being addressed. In order to overcome this potential risk, the survey is being evaluated by educators including doctorates of technology and engineering education as well as 7th grade technology educators for clarity and grade-level appropriateness. In addition, there is an option of I do not know for each statements, such that the student feels that when they do not have enough information about the statement to agree, be neutral, or disagree there is an appropriate choice. The survey will take 20-25 minutes to complete and includes statements about their interest in engineering and technology in school and for a career, if they think boys or girls are better at engineering and technology, and how they think engineering and technology effect the world.

The purpose of this letter is to inform parents of the study and to obtain approval that your son/daughter participate in the study. Participation in this study is voluntary in nature and students are free to withdraw from the study at any time without consequences. In addition, any data collected will be conducted in a manner so that all students will remain anonymous. Any information collected will be kept in a locked office and only Kari Cook will have access to it.

If you approve of your son/daughter participating in the survey, please sign the agreement form at the bottom of this page and have your student return this form to his/her teacher by (_______).

If you have you have any questions about your child's rights as a research participant, please feel free to contact Christopher Dromey, PhD, Internal Review Board Chair, (801)422-6461, 133 TLRB christopher_dromey@byu.edu. If you have questions about the specific study, please feel free to contact myself, Dr. Steven Shumway, or Dr. Ronald Terry.

Thank you for your cooperation,

Kari Cook

I (Print) __________________________________ , give permission for my son/daughter,

______________________________to participate in this survey.

Signature of Parent/Legal Guardian _______________________ Date__________

APPROVED EXPIRES
OCT 15 2007 - OCT 14 2008

Youth Assent: I understand that my parent (s) has/have given their permission for me to participate in this study. However, should I choose not to participate, I do not have to.

Youth Signature ________________________ Date________

There will be an opportunity to share additional information about student understanding or attitude towards technology and engineering through an informal interview, which will not exceed 10 minutes. If you give permission for your son/daughter to participate in such an interview and they understand they can choose not to participate, please both initial below.

Initial of Parent/Legal Guardian ______ Youth Initial _______

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