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An Investigation of the Impact A ROV Competition Curriculum has on Student Interest in sTEm, Specifically Technology and Engineering

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ABSTRACT

An Investigation of the Impact A ROV Competition Curriculum
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Technology and Engineering

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This research investigates the impact a Remotely Operated Vehicle (ROV) program has on student interest in, and perception of, technology and engineering (sTEm). ROV programs embed areas of science, technology, engineering and math (STEM) into their curriculum; however, emphasis for this study is placed on interest and perception of the “T” and “E” of STEM. Although there are many articles detailing the benefits of ROV programs, there is little empirical data documenting the impact on student interest and perception of sTEm. This study outlines the background of a few major ROV programs in the U.S.; specifically Utah Underwater Robotics (UUR), an ROV statewide program within a landlocked state, the methods for gathering data and findings from a sTEm survey instrument administered to over 300 students ranging from 6^{th} to 12^{th} grade who participated in a five-month ROV program and near 50 students who did not.

Key findings include: 1 – Males were more interested in technology *and* engineering than females, regardless of whether they participated in the UUR ROV program. 2 – Male and female students in the UUR program were more interested and had a more positive perception of engineering than those who did not participate in the UUR ROV program. 3 – Females in the UUR program reported more interest in engineering careers and activities than females not in the program. 4 – Females in the program reported more interest and self-efficacy in science than females not in the program. 5 – Males in the UUR program reported more awareness of the positive and negative consequences of technology and engineering than those who did not participate.

Keywords: STEM education, science, technology, engineering, remotely operated vehicle, ROV, PATT assessment, SeaPerch, MATE, robotics, utah underwater robotics, UUR.

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1 INTRODUCTION

There are concerns about the dwindling labor pool of technically trained personnel who have scientific, technical, engineering, and mathematical (STEM) skills and abilities (Butz et al., 2004; PCAST, 2012; Xue & Larsen, 2015). These areas are vital to American competitiveness in an expanding global economy and technically advancing global market. America's STEM industries need college graduates and others proficient in STEM to meet industrial needs and progressing technological advancements (BHEF, 2010; Bybee & Fuchs, 2006; Rothwell, 2013). Regrettably, according to the National Science Board Science and Engineering Indicators, in the past five years, 15.6 percent of bachelor's degrees were awarded in STEM fields in America. Among other world competitors, China and Korea awarded more than that number, reaching 46.7 and 37.8 percent in STEM related bachelor degrees (National Science Board, 2010).

Additionally, STEM education at elementary and secondary levels lag behind other countries. The National Assessment of Educational Progress reveals less than only one-third of U.S. eighth graders are proficient in math and science (STEM Education Coalition, 2011). The STEM program must be a priority on national, state, district and school levels if the U.S. is to catch up and exceed demands and expectations to continue to compete in the global market. One of many initiatives attempting to remedy these demands and concerns is secondary educational STEM project-based learning activities (Welch & Huffman, 2011). One such activity, which this study investigates, is the designing, building, and driving of remotely operated vehicles (ROVs).

ROVs have been used in education as early as 1992 for the purpose of applying science and engineering knowledge, tools and techniques to teach about the marine environment (MATE, 2015) and to increase the number of skilled technicians to work in "strategic advanced-technology fields" (Nichols & Williams, 2009). Educational programs that have used ROVs suggest ROV-based curriculum and activities can be a tool to enhance interest and improve perception regarding technology and engineering (Hurd, Hacking, Damarjian, Wright, & Truscott, 2013; Melchior, Cohen, Cutter, Leavitt, & Manchester, 2005). There is, however, limited research on the impact an ROV activity or program has on increasing student interest and perception of technology and engineering. Programs such as SeaPerch (AUVSI Foundation, 2013; Heilman, 2015), Utah Underwater Robotics (Hurd et al., 2013; Wright, Hurd, Hacking, & Truscott, 2014), Summer Bridge Program of 2011 (Jassesmnejad et al., 2012), WaterBotics (Eguchi, 2014; B. McGrath, Sayres, Lowes, & Lin, 2008) and MATE (Clough & Lundsford, 2006; J. Zande & Sullivan, 2003) all use underwater robotics as part of STEM curriculum. Within each program, online news articles, videos and various journal and research articles show evidence of increased student engagement and interest in STEM-related areas, robotics efficacy and STEM learning in general (Heilman, 2015; B. McGrath et al., 2008; Stolkin et al., 2007). Most of the evidence from these ROV programs speaks to the *procedures* and qualitative outcomes of the activity, not to valid data from reliable assessment instruments supporting the impact the program has on student interest and perception.

A few studies unrelated to ROVs, but associated with investigating student interest and perception of technology have used survey-assessment instruments such as the Technology Attitude Scale (TAS) (Jeffrey, 1993) and the Pupils' Attitude Towards Technology (PATT) survey-assessment (Ardies, De Maeyer, & Gijbels, 2013; Bame & Dugger Jr, 1990). A limitation of these instruments is that they do not include assessments of attitudes toward, or interest in, engineering. Consequently, there is limited research implementing the TAS and PATT survey-assessments to investigate pupils' interest and perception of technology *and* engineering.

Koycu and de Vries (2011), Jeffrey (1993), Volk et al (2003), Cunningham (2005) and Cook (2009) all however, used or referenced the PATT survey-assessment and the TAS for investigating students' thoughts and attitudes about technology and engineering. They each implemented various methods including classroom observations, new course curricula, surveys and tests, and personal or focus group interviews. Details of these studies are discussed in the review of literature.

1.1 Problem Statement

There is limited research on the impact an ROV activity or program makes regarding student interest and perception of technology and engineering. Furthermore, there is limited research using a reliable assessment instrument to investigate not only attitude and interest and perception of technology, but also of engineering, after participating in an ROV program. This research study used quantitative (a "3-in-1" assessment instrument) and qualitative (observations and focus group interviews) methods to investigate the impact the Utah Underwater Robotics (UUR) program had on student interest and perception of technology and engineering. A control and treatment methodology was used in this study.

1.2 Research Question

The research question investigated was: How does participation in a 5-month ROV experience impact 6-8th grade students' interest in, and perception of, technology and engineering? ROV programs embed areas of science, technology, engineering and math (STEM) into their curriculum; however, emphasis for this research is placed on interest and perception of the "T" and "E" of STEM. Thus, throughout this research paper STEM will be referred to as sTEm (lowercase "s" and "m").

1.3 Meaning of Interest

The purpose for including literature on interest is to clarify what is to be understood by "*interest in"* referred to in the current research question. *"Interest in"* refers to a student showing and responding with an "observable triggered or maintained situational interest." (S. Hidi & Renninger, 2006)

Consequently, "student interest" in this study was measured by students' focus group interview and survey responses. The difference of the control and treatment student responses within specific factors of the amended survey, such as Technology/Engineering career aspirations and interest in technology or engineering were used to measure interest significance. The focus group interviews facilitated the measuring of the difference of interest by students showing or demonstrating an observable triggered or maintained situational interest as described by Hidi and Renninger (2006) in the review of literature.

1.4 Meaning of Perception

Perception can be split into two processes: 1) Bottom-up processing and 2) top-down processing. Bottom-up begins with the basic information units that serve as a foundation for recognition. Top-down processing is guided by knowledge, expectations and other psychological factors (Bernstein, 2010). Both processes are considered in this study because the level of 6th to

8th grade students' experience with technological and engineering concepts and tools specific to the UUR program vary from foundational basic information to previous experience, knowledge, and expectations.

1.5 Definition of Technology

For the purpose of this study, the definition of technology referred to in the research question comes from the International Technology and Engineering Education Association (ITEEA). As described by ITEEA's *Standards for Technological Literacy: Content for the Study of Technology Education,* technology is "the modification of the natural world to meet human wants and needs." (ITEEA, 2007)

1.6 Definition of Engineering

This study references the Accreditation Board of Engineering and Technology (ABET) for the meaning of engineering as used in the research question. ABET defines engineering as "the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind." (ABET, 2015)

1.7 Method of Data Collection

Data was collected in three ways: 1) student control and treatment responses to a "3-in-1" assessment explained below, 2) observations made at the Utah Underwater Robotics 3rd annual ROV competition held March 18, 2015, and 3) focus group interviews with 54 elementary students who participated in the UUR ROV competition.

In previous years the UUR program administered a survey-questionnaire, which consisted of two categories of statements and questions focused on STEM interest and STEM perception. Alone, the original survey-questionnaire was determined inadequate for the purpose of this study. Consequently, the researchers wanted to include a reliable assessment instrument, and the PATT-USA assessment-modified from the European 1985 PATT-was chosen as this reliable instrument. The PATT-USA was chosen because of its proven reliability as an instrument from the field of technology education.

At the time of this study, the PATT-USA assessment did not include statements regarding engineering. Thus, the researchers created their own modified version of the PATT-USA, called the Pupils' Attitude Towards Engineering (PATE). This survey-assessment includes identical statements and categories of the PATT except wherever the word *technology* is used, *engineering* is put in its place.

Thus, the final survey assessment used for this study consists of three assessments, the PATT-USA, PATE and original UUR STEM questions combined into one instrument. This assessment is further referred to as the "3-in-1." The 3-in-1 assessment was administered to a control and treatment group.

1.7.1 Participant Selection Method

Participation in the UUR program is voluntary. Interested teachers, after school coordinators, or parents simply signup for the UUR using the online portal. It is a free program, which provides ROV supplies, training, and curriculum support.

Teachers who decide to use it in school, embed the curriculum and design process activities into their regular class time schedule. Students in these situations do not self-select into the UUR program. Approximately 75% of the participants are from schools where UUR has been embedded into the regular school day and curriculum. Teachers or parents who participate in UUR as an after school club activity or at home, are invited to also use the same curriculum, however, in this case, the students generally have self-selected into the program.

The focus group methods of this study involved two classes whose teachers used the UUR program as part of their science curriculum during school. Thus, qualitative findings of this study represent a sample population of students who mostly experienced UUR as part of their school day. Consequently, the focus group method also used a sample population of students who only participated in UUR because it was part of their regular school day.

1.8 Method of Data Analysis

The analysis of the data consisted of two parts. First, descriptive statistics based on control and treatment responses to a 3-in-1 survey assessment were calculated using the Wilcoxon-Mann-Whitney/Kruskal Wallis test—a Chi square nonparametric test—and Dunn's Method for Joint Ranking analyses. Where applicable, these statistical analyses were performed on two main categories of the 3-in-1 assessment, each category consisted of eight subcategories. The two main categories of the 3-in-1 are: 1) controlling for treatment, and 2) controlling for gender and treatment. The subcategories for each main category are the same across each main category. The subcategories are: 1) the composite score for the entire PATT-USA assessment, 2) the composite score for the entire PATE assessment, 3) the composite scores for each of the six categories in the PATT-USA assessment, 4) the composite scores for each of the six categories in the PATE assessment, 5) the individual statement scores in the PATT-USA assessment, 6) the individual statement scores in the PATE assessment, 7) the original UUR STEM questionnaire; categorized by individual questions regarding interest in STEM, 8) the original UUR STEM survey questionnaire; categorized by individual questions regarding STEM perception and 9) the composite score for questions regarding STEM perception in the original UUR STEM questionnaire.

The second part of the data analysis involved identifying patterns and themes from the qualitative analysis of the observations and focus group interviews. A constant comparative method, as outlined by Glaser and Strauss (Glaser & Strauss, 2009), Strauss and Corbin (Strauss & Corbin, 1990), and Charmaz (Charmaz, 2014) was used to analyze the observations and focus group interviews. Chapter three details this analytical method.

2 REVIEW OF LITERATURE

There is limited literature that discusses the significance an ROV program has on student interest and perception of technology and engineering in an educational setting. Most of the literature involving the use of ROVs consists of a study or report of the curriculum and experiential design for that particular program. For example, several of the reports include the results of participants' accomplishments, and in some cases participants' perceptions or feelings about the program. Additionally, literature describing the instruments used for analysis of the impact the particular ROV program had on the participants' interest is limited. Because of the limited literature related to this current study, efforts for this study were focused on pertinent literature implementing the use of ROVs as a STEM-related activity in an educational setting and primarily aimed at showing the similarities and differences of programs and practices in comparison to this study's ROV program investigation. Literature on valid and reliable instruments quantifying interest and perception of technology and engineering was also consulted.

2.1 Underwater ROV Programs: What Impact do They Have on Students' Interest in, and Perception of, sTEm?

Building robots, specifically underwater remotely operated vehicles (ROVs), is one promising and developing approach where the impact indicates an increase in sTEm interest among elementary and secondary students (Eguchi, 2014; Jassesmnejad et al., 2012; Nugent, Barker, Grandgenett, & Adamchuk, 2010; Wright et al., 2014). The building and operating of an underwater ROV is an increasingly popular activity in sTEm education because of its capacity to implement science, technology, engineering, and mathematical principles as part of its function (Wright et al., 2014). In the United States there are several ROV programs offering a variety of opportunities to apply engineering-type skills and experiences that may lead to an increase in sTEm interest. The SeaPerch, WaterBotics, MATE and Utah Underwater Robotics programs are discussed below.

2.1.1 SeaPerch

For the past 12 years, K-12 students involved in the SeaPerch program have built underwater ROVs and learned about basic engineering and science concepts with a marine engineering theme. The building of an underwater ROV, and applications of ROV-related engineering and science content taught through the program has been designed to meet many learning standards and outcomes according to the curriculum outline on the SeaPerch website. Standards and outcomes include: ship and submarine design, buoyancy/displacement, propulsion, vectors, electrical waterproofing, soldering, ergonomics, depth measurement, biological sampling, attenuation of light, basics physics of motion, tool safety and usage, and career possibilities (AUVSI Foundation, 2013).

Various news articles and media publications involving the SeaPerch program describe the procedures and accomplishments of students participating in the program. One such news article written by Luci Weldon, interviews Marissa Sherrill as she describes her students' actions during a robotics course at Warren New Tech High School in North Carolina,

> “Students research the types of robots developed around the world and how they are used in various settings. Students’ class work involves cutting PVC pipes, using zip lines to attach the netting to the pipes for buoyancy, drilling holes to allow the vehicle to float, attaching thrusters and propellers, soldering a control panel circuit and stripping wires to connect them with the propellers.” (Weldon, 2015)

An article on the SeaPerch website indicates a positive impact on student interest in sTEm. Nothing was found that provided research-based data indicating the difference the program made in student interest toward sTEm. Notwithstanding, a student’s reflection of the SeaPerch program’s impact on his thinking, as recorded in Waves Magazine following a regional SeaPerch challenge in Maryland documents a common finding,

> “STEM influences me by showing me new ways to think and create new engineering ideas. The inventions created through STEM make engineering appealing to me for my future in deciding on college and my career path.” (Malay, 2014)

An interview in the Chicago Tribune of Commander Michael Kerley, the Midwest Outreach Officer for SeaPerch, captured the primary learning outcome of the SeaPerch program,

> “The reason this is so important is that we, as a nation, are losing our current generation of scientists and engineers. So the Navy is trying to build that next generation, using SeaPerch. The Navy is looking, proactively, to engage students in STEM subjects and get them excited.” (Bucksten, 2015)

Another article reports students’ imagination being impacted by the SeaPerch program. Devin Heilman quotes one student,

> “They (ROVs) can probably reach deeper depths in the sea," Ethan said. "I've heard on the news that for some reason our land space is not as much. Maybe someday we can make, like, an underwater robot so that people can live under the water, because there is so much room under the sea. It's just something I've thought about.” (Heilman, 2015)

After reading various articles discussing SeaPerch, similar to those listed and cited above, the data surrounding SeaPerch suggests it is having a positive impact on student interest in sTEm. However, the findings are limited to qualitative self-reporting, and there are no quantitative reports indicating evidence from data or research on the actual impact the SeaPerch program has on student interest in, and perception of, sTEm.

2.1.2 WaterBotics

WaterBotics is an underwater robotics, challenge-based curriculum where students work together to design, build, program, test and redesign underwater robots, made of Lego and other components. The program can be implemented in formal classroom environments as well as informal out-of-school settings, such as summer camps (Stevens Institute of Technology, 2015). The program focuses on the iterative design process and embeds science lessons within each design challenge to attain measurable student learning gains in physical science concepts (E. McGrath, Lowes, McKay, Sayers, & Lin, 2012).

During the research and development phase of the project, research conducted by McGrath et al measured student engagement; student learning of specific science concepts; programming skills; understanding of engineering design process, and understanding of, and interest in, engineering careers. Pre and post concept assessments and pre and post implementation surveys were collected. Due to various factors such as students transferring from class before the end of the course and the long cumbersome multiple choice post assessment, the number of assessments collected varied from year-to-year and assessment-to-assessment. Findings related to a change in students' understanding of the engineering design process was less than expected, showing only about 25 percent of students able to describe any of the steps in the engineering design process (E. McGrath et al., 2012). Additionally, students demonstrated a very narrow conception of what constitutes engineering. About two thirds of the middle school students wrote that engineers were involved in designing and building. The majority thought engineers designed, built or fixed cars, machines, electronics, or other mechanical objects. This led to a major enhancement of the WaterBotics curriculum, which was to build the curriculum, the assessments, the surveys, and the classroom management tools into one learning management system (E. McGrath et al., 2012). After the major enhancements, findings demonstrated an increased understanding of the engineering design process and related engineering processes.

Formal (the classroom) and informal (summer camp) sites were one of the major enhancements that impacted students' interest and understanding. In 2013, research findings suggested that if students in both formal and informal environments enjoyed the curriculum, there was a strong possibility that students learned. McKay further states,

> "Contrary to the original hypothesis, students from the informal hub sites did better on content learning than students in formal classrooms. On the other hand, the informal sites did better on STEM interest and engagement, as hypothesized."
>
> "…our recent analysis indicated that teacher/educator knowledge of the topic was not correlated with student post-test scores for any topic except programming. This may be due to the expanded instructions, descriptions and images, and educator resources now available in the curriculum, especially in the informal educator version, which has more step-by-step guided instructions and explanations."
>
> "Overall, the curriculum has worked best in the informal environments… Engagement was higher at the informal sites, they did more with engineers and engineering, and participants did better on the assessments." (McKay et al., 2013)

2.1.3 MATE

The Marine Advanced Technology Education (MATE) Center is a national partnership of organizations working to improve marine technical education and in this way help to prepare

America's future workforce for ocean occupations. Headquartered at Monterey Peninsula College (MPC) in Monterey, California, the MATE Center has been funded as a National Science Foundation (NSF) Advanced Technological Education (ATE) Center of Excellence since 1997 (MATE, 2015).

The MATE Center has developed a model for gathering information on the marine work force and providing educators and students with that information. This model assesses marine work force needs and uses those needs to develop knowledge and skill guidelines (KSGs). These KSGs have been used, in turn, to create educational curriculum based on marine industry requirements, or competencies that are common to two or more occupations. The MATE organization works closely with community colleges, high schools, universities, research institutions, marine industries, professional societies, and working professionals to facilitate connections among industry mentors, educators and students, as well as the development and use of industry-based KSGs. (Jill Zande, Sullivan, Butcher, & Murphree, 2002). Thus, students who choose to participate, have an opportunity to earn certificates, skills transferrable and make personal connections with professionals and careers within the marine technology and ocean economy workforces.

There are limited research articles and empirical data analyses indicating the impact the MATE program has on student interest and perception of technology and engineering. There are however, many articles reporting MATE-funded curriculum and competitions and the specific learning outcomes, objectives and student experiences related to technology and engineering. Jill Zande and Deidre Sullivan explain an example of the possible outcomes and impact these competitions have on students:

> "These competitions involve budgeting, setting deadlines, documenting procedures and results, and producing deliverables on time - just like the real working world. Building an ROV to successfully complete a competition mission not only involves a practical, working knowledge of math, subsea physics, electronics, hydraulics, and engineering; it also requires project management, written and verbal communication, teamwork, critical thinking, and continual problem solving. The competitions also promote creativity and innovation, both of which could someday lead to the development of technologies that advance ocean exploration, research, and industry." (J. Zande & Sullivan, 2003)

Zande does not make clear the method for assessing the level of impact competitions have on students, however, the specific curriculum objectives and level of engagement from the students is a major factor for the level of achievement and learning of students in the program.

Another example of how MATE underwater ROV programs impact student interest and perception in technology and engineering comes from the Leadership magazine article titled "Diving Into Real World Challenges" published by the Association of California School Administrators (Saldaña & Rodden, 2012). The article reports that through the Long Beach City College Robotics program, students at Beach High who participate in their underwater ROV program "build technical knowledge and skills…develop the ability to problem-solve, think critically, and work as part of a team." The program assesses students' learning by their ability to complete the "real world problems" specific to the competition. This process is supported by the California Common Core State Standards, which suggests that allowing students to grapple with real world problems brings relevance to their academic studies and connections to future careers.

The MATE program appears to have a significant impact on student interest and perception of technology and engineering within marine-related technical careers. By designing and building ROVs, "participating in real-world competition scenarios and coming into direct contact with industry professionals, students apply STEM skills in a fun and exciting manner." (J. Zande & Brown, 2008)

2.1.4 Utah Underwater Robotics

The Utah Underwater Robotics (UUR) program recently finished its third consecutive year of operation. MIT graduate Dr. Tadd Truscott, then working as a mechanical engineering professor at Brigham Young University (BYU), instigated UUR. Dr. Truscott decided to involve BYU and surrounding communities in an effort to excite young students about STEM topics (Hurd et al., 2013). The UUR curriculum was influenced by Dr. Truscott, which he developed from the structure of the SeaPerch program, and was initially partially funded by a grant from the Office of Naval Research (ONR).

Before March 2015, the UUR survey instrument assessed each student's interest and self-efficacy in STEM (Wright et al., 2014). The assessment was influenced by related STEM assessments, such as the STEM semantics survey and the STEM Career Interest Questionnaire (Tyler-Wood, Knezek, & Christensen, 2010). The assessment asked questions regarding students understanding of STEM principles, interest in STEM topics, careers, and fields of study. According to Wright, in that first year of study, quantitative data received from the surveys did not reveal that the ROV activity had made any statistically significant impact on student interest in STEM areas. Researchers still believed, however, based on observations, and on teacher, student, and administrative feedback, that the ROV program had potential to impact student interest in STEM. Researchers acknowledged the need to further develop and improve research methods, curriculum, and associated theories. Wright reported that:

> "Additionally, we intrinsically believe (based on personal beliefs and observations) that contemporary and blended STEM curriculum such as ROV (underwater technology) can effectively promote STEM interest and ability; therefore, there is a need to develop and evaluate the curriculum and associated theories. This research effort is a start in this direction." (Wright et al., 2014)

The Utah Underwater Robotics (UUR) program is included in this literature review to acknowledge incomplete empirical data supporting claims of the impact the program has on students' interest in sTEm. For example, the UUR program lacks a qualitative component investigating student interest in, and perception of, technology and engineering. It is the belief of the researchers that by adding a qualitative component to the current study, and by further developing the quantitative measures, it may be possible to determine statistical significance of the impact UUR has on student interest in sTEm. When accomplished, data and methods from this study may assist other ROV programs in determining their own significance and the ability to provide statistical evidence to support their claims.

2.2 Instruments that Measure Student Attitudes, Perceptions or Interest in STEM; Specifically Technology and Engineering

2.2.1 The TAS and PATT

Reliable data concerning student attitudes, interests, and perceptions of technology as a single topic of focus, have come from the development and use of the Technology Attitude Scale (TAS) and Pupils' Attitude Towards Technology (PATT) survey-assessment. The TAS, derived from a large-scale PATT study, was developed for individual middle school classroom teachers to ascertain student attitudes and concepts regarding technology. The TAS was first developed by de Klerk Wolts in 1987 and later adapted and validated by Thomas Jeffrey for the purpose of teachers administration in American middle schools (Jeffrey, 1993). Although the TAS was developed as a shorter alternative to the PATT to be used in classrooms, many studies also used the TAS as an instrument to measure teachers' attitudes towards technology, and how it effects technology use in the classroom (Galowich, 1999; McFarlane, Hoffman, & Green, 1997; Pierce & Ball, 2009).

Conception of the PATT assessment began in 1984 by Raat and de Vries as a pilot study to determine 13-14-year-old students' attitude towards technology. The initial research included countries across the world including Australia, Belgium, Canada, Hungary, Kenya, Nigeria, Poland, Sweden, the UK and the USA (Raat & de Vries, 1985). The first PATT assessment studies were developed at the Eindhoven University of Technology in the Netherlands. In 1989 the PATT assessment was refined and reduced to include 24 statements. The result was the PATT-USA survey (Ardies et al., 2013).

2.2.2 The DAET and TEAS

Cunningham (2005) assessed elementary school students' conceptions of engineering and technology by modifying the "Draw a Scientist Test" (Chambers, 1983), creating a "Draw an Engineer Test (DAET)." The test had four components. First, students were asked to circle the kinds of work that engineers do from 16 images and descriptions of people at work. Second, the students were asked to complete the phrase, "An engineer is a person who…" Third, 16 images and descriptions about technology were provided, and students were expected to circle those items that they defined as being technology. Finally, students were asked to respond to the open-ended question, "How do you know if something is technology?" (Cunningham, Lachapelle, & Lindgren-Streicher, 2005)

Results from Cunningham's research found student conceptions and misconceptions from previous research studies consistent with her own. Students lacked the understanding about the breadth of the fields that utilize engineering, yet strongly associate construction workers and auto mechanics with engineers. Cunningham noted, “Children are more likely to think that engineers clean teeth than design ways to clean water.” (Cunningham et al., 2005)

Another instrument that measures student attitude and perception of STEM comes from the Technology and Engineering Attitude Scale (TEAS). Kari Cook investigated middle school student interest, perception, and attitude toward technology and engineering before and after taking a technology-engineering course. Additionally, Cook wanted to better understand how the gender of a teacher or student and the information provided in technology classes affected student perception and attitude. The PATT and TAS were referenced in the study, which led to the creation of the TEAS (Cook, 2009). Findings from the study revealed that male students showed higher learning and career interest before the course, while the female student interest increased significantly over the term of classroom instruction.

Most of the research using the PATT assessment has focused on students involved or not involved in technology courses or other engineering design curriculum. Although there is research using the PATT assessment to evaluate student interest and perception in technology and engineering, it has not been used in an ROV research application.

The review of literature revealed the PATT-USA (Ardies et al., 2013; Bame & Dugger Jr, 1990) survey assessment as a good choice to include in this research for two reasons: 1) the PATT assessment has been used in numerous technology and engineering education settings, more than that of the TAS, and 2) the PATT-USA contains 24 statements for students to respond to, whereas the TAS contains 54 statements, many of which are redundant. The researchers believed survey fatigue with the participants (ages: 10 – 16) would be an important issue to accommodate.

2.3 Student Concept of and Attitude Towards Technology and Engineering

Raat and de Vries found that student technological attitude was primarily influenced by: (1) interest in technology, (2) perception of gender differences, (3) diversity of technology, and (4) importance of technology. In addition, their research showed that students had a vague concept of technology, and females were less interested in technology and found it less important than their male peers (Raat & de Vries, 1985). In 1989, Bame and Dugger found that students were generally interested in technology, and males yielded greater interest than females. However, both male and female students continued to demonstrate a narrow concept of technology (Bame & Dugger Jr, 1990).

Volk et al. (2003) performed two studies to determine students' attitude towards technology. One study was performed before the introduction of a Design and Technology course in several secondary schools. The course was the first to include girls in a subject that was predominantly male. The second study was performed five years after implementation of the Design and Technology course. Volk reported the following,

> "…it appears that the inclusion of girls in Hong Kong D&T programs is having a positive impact on students' attitudes toward technology, with the differences between boys' and girls' attitudes disappearing for some categories. The type of program and resulting learning experience also impact students' attitudes, suggesting that programs that are more innovative and less craft- and skill-based are more successful in influencing attitudes. This should provide evidence to educators and the public as to the educational value of the subject."

Koycu and de Vries investigated what upper secondary school children think about engineering by incorporating a questionnaire similar to the PATT. Concept maps were incorporated in the study to see how students think about engineering concepts. The specific questions on their modified questionnaire were not available, but their conclusions indicated that upper secondary students had a fairly good idea of what engineering was and that they had a positive attitude towards it (Koycu & de Vries, 2011).

2.4 Relationship Between Technology and Engineering

One of the most common threads between technology and engineering concerns misconceptions of understanding what they both are. When asked to define technology many individuals suggest it is the application of science or applied mathematics. Although this definition has a long standing in this country (Stokes, 1997), it does not envelope technology in modern context. Within the educational and societal realm, many individuals and educators refer to technology education as the simple use or integration of computers and electronic or digital devices (William E. Dugger, Gallup, Rose, & Starkweather, 2004; Utah State Board of Education, 2012). A different and more accurate definition comes from the ITEEA: "[*any*] modification of the natural world to meet human needs and wants" (Williiam E. Dugger; ITEEA, 2007). On the engineering side, although conceptual understanding of engineering and what engineers do may be better understood than that of technologists and technology, children and adults have been shown to still have a narrow idea of what engineering is (Cunningham et al., 2005; National Academy of Engineering, 2008).

A few distinctions between technology and engineering involve how tools are used, the educational goals within each pathway to professionalism and the application of mathematical and scientific concepts within the design process.

> "Engineering is the domain of professions concerned with the development and maintenance of technological devices and systems. The work of engineers is to design new technological solutions to practical problems, or to improve existing systems using the design process. In order to do this, engineers use knowledge about the physical and chemical phenomena that underlie the functioning of artifacts and systems. They also use

knowledge of mathematics for modeling and making calculations." (Dakers & de Vries, 2009)

Although technology education features the capabilities of the design process, it is devoted to a broader goal of achieving technological literacy for all (Daugherty, 2009) compared to the more in-depth specialized form of engineering education. Technology education also considers what users need to know and be able to do. The ITEEA is determined to deliver technological literacy for all, not just those studying technology.

"As a result of studying technology in Grades K-12, students gain a level of technological literacy that may be described as one's ability…to use, manage, assess, and understand technology." (ITEEA, 2007)

Another distinction between engineering and technology is the level of experiential technological application. Research states "students learn best in experiential concrete ways rather than only through visual or auditory methods" (ITEEA, 2007). In other words, Technology education conducts activities and experiments that reflect the development and use of technology in the real world.

Design is the fundamental link between both technology and engineering education. Engineering design is the process of devising a system, component, or process to meet desired human needs and wants (Daugherty, 2009). The engineering design process is best known for its iterative decision-making process. In the process basic science, mathematics, and technological knowledge are applied to optimally meet a stated objective. Technologists use the design process a little differently in that they rely on the practical implementation of known solutions to similar problems (Daugherty, 2009). In so doing, the solutions may be moderated by experiences, societal values, and available resources. Whether an engineer or technologist achieves an optimal solution, the approach taken by either profession will implement some version of the engineering design process. To summarize the relationship between technology and engineering, according to the ITEEA, technological literacy is the ability to use, manage, understand, and assess technology, but does not completely include the ability to improve or create new technologies. Engineering literacy is the ability to solve problems and meet goals using the engineering design process.

2.5 Interest

The purpose of this study is to investigate the question, "How does a five-month ROV curriculum and competition impact student *interest* in, and perception of, sTEm?" The review of literature revealed the term *interest* having multiple definitions each dependent on the researcher reflecting the theoretical perspectives and goals of their research (Swarat, Ortony, & Revelle, 2012). According to the literature and for the purpose of this study, "*interest in"* refers to students showing and responding with an observable triggered or maintained situational interest (S. Hidi & Renninger, 2006).

In the study titled, Igniting and Sustaining Interest Among Students Who Have Grown Cold Toward Science, Jack (Jack & Huann-Shyang, 2014) presents ideas on the nature of interest. For this review of literature, three concepts were extracted to better clarify the meaning of "interest" relating to the purpose of the current study and the impact of an ROV program has on student *interest* in sTEm. The three ideas are: (a) characteristics of the nature of interest, (b) individual (indirect) interest, and (c) situational (direct) interest.

Jack presents three characteristics of the nature of interest that reflect the traditionally recognized views of past and present scholars.

1. Interest is biased in disposing a person toward certain behaviors only if an object or activity of interest is present.

2. Interest is dynamic in disposing the person toward seeking out additional experiences that provide continued or repeated interaction with the interest object or activity.

3. The third characteristic of interest is its mediated changeableness, which is affected by the process of *internalization* and refers literally to the taking in of something from the outside.

Deci et al (2000) expounds on the meaning of *internalization* as being either introjection or integration:

> "…introjection internalization as acceptance of something without desire to take full ownership, and integrated internalization as acceptance of something along with the desire to take full ownership." (Deci, Eghrari, Patrick, & Leone, 1994)

Also, Dewey (Dewey, 1913) goes into more detail about how such mediated changeableness of interest is indirect or transferred interest,

> "We have cases of indirect, transferred, or technically speaking, mediated interest. Things indifferent or even repulsive in themselves often become of interest because of assuming relationships and connections of which we were previously unaware. Many a student, of so-called practical make-up, has found mathematical theory, once repellent, lit up by great attractiveness after studying some form of engineering in which this theory was a necessary tool." (Dewey, 1913)

An example of introjection internalization relating to underwater ROVs would be students learning science, engineering, and technology content embedded in the ROV curriculum without understanding how such learning is meaningfully relevant to their lives. It is only when students are able to see and understand how the learning of science, engineering and technology content embedded in the UUR curriculum is meaningfully relevant to them, that interest moves from introjection to integration internalization.

Jack further depicts two additional aspects of interest that relate to the nature of this study, they are: 1) individual/personal (indirect) interest and 2) situational (direct) interest (Jack & Huann-Shyang, 2014). Individual interest is characterized by a disposition or personal preference for a subject-specific domain (A. S. Hidi, 2002; S. Hidi & Renninger, 2006; Krapp, 2002). In the early 90's, individual interest was sub-classified into latent interest and actualized interest (S. Hidi, Krapp, & Winteler, 1992). Referencing Schiefele, Jack explains that "latent interest refers to the feeling and value-related interest a person has developed over time for a topic-specific domain. Schiefele and colleagues (S. Hidi et al., 1992) view actualized interest as the excitation of a person's individual interest by some aspects of his or her present environment." (Jack & Huann-Shyang, 2014)

Situational interest, unlike individual interest, is a measure of the observable aspects of a person's disposition or preference towards a specific object, topic, or learning task within a particular situation (S. Hidi & Renninger, 2006). Hidi and Renninger stated that situational interest could be triggered or maintained:

> *"Triggered situational interest* refers to a very short propulsive or impulsive phase of interest initiated by an external agent that excites students' interest in learning a specific topic (van der Hoeven Kraft, Srogi, Husman, Semken, & Fuhrman, 2011)… Reinforcing this triggered interest through engaging activities that provide a student with success and/or positive feedback has over time the potential to develop into an individual interest." (S. Hidi & Renninger, 2006)
>
> *"Maintained situational interest*, unlike the short-lived propulsive or impulsive triggered interest, is the strengthening (i.e., reinforcement) of a previously triggered situational interest through continued meaningful connections with the object of that interest" (Dohn, 2011a; Hidi & Renninger, 2006). Referencing Dewey, Dohn (2013) stated: "Maintained situational interest is a more committed, deeper form of situational interest, in which individuals forge a meaningful connection with the content of the material and realize its deeper significance."

The purpose for reviewing the above literature is to clarify what is to be understood by "*interest in"* referred to in the research question, "How does participation in a five-month ROV experience impact 6-8th grade students' interest in, and perception of, technology and engineering (sTEm)?" According to the literature and for the purpose of this study, "*interest in"* refers to students showing and responding with an observable triggered or maintained situational interest (S. Hidi & Renninger, 2006).

3 METHODOLOGY

3.1 Collecting Data

In order to answer the research question, data was collected in three ways. The first was through observations made at the Utah Underwater Robotics (UUR) 3rd annual ROV competition on March 18th 2015. The second was based on student control and treatment responses to a "3-in-1" assessment instrument. The third was from focus group interviews with 54 sixth-grade students who participated in the UUR ROV competition.

3.1.1 Participant Selection Method

Participation in the UUR program is voluntary. Interested teachers, after school coordinators, or parents simply signup for the UUR using the online portal. It is a free program, which provides ROV supplies, training, and curriculum support.

Teachers who decide to use it in school, embed the curriculum and design process activities into their regular class time schedule. Students in these situations do not self-select into the UUR program. Approximately 75% of the participants are from schools where UUR has been embedded into the regular school day and curriculum. Teachers or parents who participate in UUR as an after school club activity or at home, are invited to also use the same curriculum, however, in this case, the students generally have self-selected into the program. The UUR participant responses to the 3-in-1 survey assessment reported 62% male.

The focus group methods of this study involved two classes whose teachers used the UUR program as part of their science curriculum during school. Thus, qualitative findings of this study represent a sample population of students who mostly experienced UUR as part of their school day. Consequently, the focus group method also used a sample population of students who only participated in UUR because it was part of their regular school day.

3.1.2 Control Group Selection

In this study it was not possible to administer the 3-in-1 survey-assessment before the 2014-2015 ROV competition. Because of this it was decided that a control group of students who did not participate in the UUR program be identified and take the 3-in-1 survey. The control group was chosen based on the following criteria: 1) Students from the same school as those who participated in the ROV program and 2) students of the same age and grade of those who participated in the ROV program.

At the time of the study, all control group participants were 11-12 years old and attended the same school as participants in the focus group interview (also 11-12 years old). Students in the control had a similar learning environment as participants in the interview focus group, and had taken similar technology classes as participants in the UUR program of ages 11-12. The control group responses to the 3-in-1 survey assessment reported 48% male.

3.2 Observations

Notes and observations of over 400 students preparing and competing using their personally built ROV were aggregated during the 3rd annual Utah Underwater Robotics competition, held on March, 18th 2015, in Lehi Utah. The local recreation center included a 25-yard, 8-lane pool where students conducted their ROV team challenges.

A few teachers, principals and students were asked questions as the researcher roamed the competition collecting field-notes and observing participants as they competed. Questions posed to present principals and teachers included: What impact do you think this ROV program has on the students? Did you see a difference in student classroom behavior or engagement prior to the competition but after the beginning of the program? What do you think the program teaches students? What would you say is the best thing about the program?

Students were asked questions such as: What was one thing you learned from this experience? How did you build your ROV? What was the best part of your experience? Would you do this again if you had the chance? Teams were also asked questions about how prepared they felt for the competition. Questions were informed by the type of questions found in the PATT assessment as well as from the overall purpose of the research: investigating how an ROV program impacts student interest in, and perception of technology and engineering,

Observations also included the reactions and comments students were having with each other during their assigned competing timeslot. Students were also observed as they came into the competition arena and swimming pool deck. Teams were observed as they waited their turn to compete. Student, parent and teachers' behavior and conversations after the competition, and their reactions during the awards ceremony were all observed and noted. Finally, observations of students' poster presentation explanations of how they built their ROV and what they learned from the activity were also collected.

3.3 Surveys

In previous years the UUR program administered a survey-questionnaire, which consisted of two categories of statements and questions focused on STEM interest and STEM perception (see Table 3-3). Alone, the original survey-questionnaire was determined inadequate for the purpose of this study. Consequently, the researchers wanted to include a reliable assessment instrument, and the PATT-USA assessment-modified from the European 1985 PATT- was chosen as this reliable instrument—Table 3-1 shows the PATT-USA assessment. The PATT-USA was chosen because of its proven reliability as an instrument from the field of technology education.

At the time of this study, the PATT-USA assessment did not include statements regarding engineering. Thus, the researchers created their own modified version of the PATT-USA, called the Pupils' Attitude Towards Engineering (PATE). As shown in Table 3-2 this survey-assessment includes identical statements and categories of the PATT-USA except wherever the word *technology* is used, *engineering* is put in its place.

Thus, the final survey assessment used for this study consists of three assessments, the PATT-USA, PATE and original UUR STEM questions combined into one instrument. This assessment is further referred to as the "3-in-1" (see Table 3-4). The 3-in-1 assessment was administered to a control and treatment group. Each piece of the 3-in-1 assessment utilizes some version of the Likert scale and represents how much the treatment and control groups agree or disagree with each question or statement on a scale of 1-5, where 1=Strongly Disagree 2= Disagree 3=Neither Agree nor Disagree 4=Agree and 5=Strongly Agree.

Table 3-1: PATT-USA Assessment Categories and Statements

PATT Categories	Individual Statements *(5 point Likert "agree" scale)*
Technological career aspirations	I will probably choose a job in technology I would enjoy a job in technology I would like a career in technology later on Working in technology would be interesting
Interest in technology	I would rather not have technology lessons at school If there was a school club about technology, I would certainly join it I am not interested in technology There should be more education about technology I enjoy repairing things at home
Tediousness towards technology	I do not understand why anyone would want a job in technology Most jobs in technology are boring I think machines are boring A technological hobby is boring
Technology is for both, Boys and Girls	Boys are able to do practical things better than girls Boys know more about technology than girls Boys are more capable of doing technological jobs than girls
Consequences of technology	Technology makes everything work better Technology is very important in life Technology lessons are important Everyone needs technology
Technology is Difficult	You have to be smart to study technology Technology is only for smart people To study technology, you have to be talented You can study technology only when you are good at both mathematics and science

Table 3-2: PATE Assessment Categories and Statements

PATE Categories	Individual Statements *(5 point Likert "agree" scale)*
Engineering career aspirations	I will probably choose a job in engineering I would enjoy a job in engineering I would like a career in engineering later on Working in engineering would be interesting
Interest in engineering	I would rather not have engineering lessons at school If there was a school club about engineering I would certainly join it I am not interested in engineering There should be more education about engineering
Tediousness towards engineering	I do not understand why anyone would want a job in engineering Most jobs in engineering are boring An engineering hobby is boring
Engineering is for both, Boys and Girls	Boys know more about engineering than girls Boys are more capable of doing engineering jobs than girls
Consequences of engineering	Engineering makes everything work better Engineering is very important in life Engineering lessons are important Everyone needs engineering
Engineering is Difficult	You have to be smart to study engineering Engineering is only for smart people To study engineering you have to be talented You can study engineering only when you are good at both mathematics and science

Table 3-3: Original UUR STEM Interest and Perception Questionnaire

STEM interest
What do you like about being in a club or classroom where you can build an ROV?
Rate how much you like science *(5 point scale)*
Rate how good you are at science *(terrible, below avg, at avg, above avg, really good)*
I would like to be an engineer someday *(5 point scale)*
I like to find out how things work *(5 point scale)*
Rate how much you like math? *(5 point scale)*
Rate how good you are at math *(terrible, below avg, at avg, above avg, really good)*
I would like to take a class about engineering *(5 point scale)*
STEM perception/self-efficacy ***(open response and 6 point agree/disagree scale)***
What is engineering? *(open response)*
What do engineers do? *(open response)*
The world has enough engineers
It is hard to find a job if you become an engineer
The most important thing about getting a job is how much money you make
I am good at science
I am very creative
What is technology? *(open response)*
Engineering improve our lives
Engineers don't make very much money
I am good at thinking up new inventions
I am good at math
An engineer is someone who uses science to build new and useful things
Variables not used in this study's analysis **but included in the questionnaire**
How much education has your father received?
What does your father do for a living?
Do you have siblings in college? What areas are they studying?
How much education has your mother received?
What does your mother do for a living?
What are some of your hobbies?

Table 3-4: 3-in-1 Survey Assessment Given to the Treatment and Control

PATT Categories	Individual Statements *(5 point Likert "agree" scale)*
Technological career aspirations	I will probably choose a job in technology I would enjoy a job in technology I would like a career in technology later on Working in technology would be interesting
Interest in technology	I would rather not have technology lessons at school If there was a school club about technology, I would certainly join it I am not interested in technology There should be more education about technology I enjoy repairing things at home
Tediousness towards technology	I do not understand why anyone would want a job in technology Most jobs in technology are boring I think machines are boring A technological hobby is boring
Technology is for both, boys and girls	Boys are able to do practical things better than girls Boys know more about technology than girls Boys are more capable of doing technological jobs than girls
Consequences of technology	Technology makes everything work better Technology is very important in life Technology lessons are important Everyone needs technology
Technology is difficult	You have to be smart to study technology Technology is only for smart people To study technology, you have to be talented You can study technology only when you are good at both mathematics and science
PATE Categories	**Individual Statements** ***(5 point Likert "agree" scale)***

Table 3-4, Cont'd.

Engineering career aspirations	I will probably choose a job in engineering I would enjoy a job in engineering I would like a career in engineering later on Working in engineering would be interesting
Interest in engineering	I would rather not have engineering lessons at school If there was a school club about engineering I would certainly join it I am not interested in engineering There should be more education about engineering
Tediousness towards engineering	I do not understand why anyone would want a job in engineering Most jobs in engineering are boring An engineering hobby is boring
Engineering is for boys and girls	Boys know more about engineering than girls Boys are more capable of doing engineering jobs than girls
Consequences of engineering	Engineering makes everything work better Engineering is very important in life Engineering lessons are important Everyone needs engineering
Engineering is difficult	You have to be smart to study engineering Engineering is only for smart people To study engineering you have to be talented You can study engineering only when you are good at both mathematics and science
STEM interest	
Rate how much you like math? *(5 point scale)*	
Rate how much you like science *(5 point scale)*	
Rate how good you are at science *(terrible, below avg, at avg, above avg, and really good)*	
I would like to be an engineer someday *(6 point "agree" scale)*	
Rate how good you are at math *(terrible, below avg, at avg, above avg, and really good)*	

Table 3-4, Cont'd.

I like to find out how things work *(6 point "agree" scale)*
I would like to take a class about engineering *(6 point "agree" scale)*
STEM perception/self-efficacy ***(6 point Likert "agree" scale)***
What is engineering?
What do engineers do?
The world has enough engineers
It is hard to find a job if you become an engineer
The most important thing about getting a job is how much money you make
I am good at science
I am very creative
What is technology?
What is the engineering design process?
Engineering improve our lives
Engineers don't make very much money
I am good at thinking up new inventions
I am good at math
An engineer is someone who uses science to build new and useful things

3.4 Focus Group Interviews

To help triangulate the data, follow up focus group interviews were conducted one week after the ROV competition. Nine groups, each group comprising 5-6 elementary students, were interviewed at their school in a study room just two doors down the hall from each student's homeroom classroom. Each interview episode lasted between 15 to 20 minutes.

Teachers of students attending the school were contacted and agreed to make time for their students to participate in the focus group interviews. The following procedures and questions were used in the focus group interviews:

1. As students came into the area where the interviews took place, the interviewer greeted them. A small connection was made as the interviewer asked them questions about school. The interviewer told the students a little about him to further create a connection with the students.
2. When the interviewer felt students were a little more comfortable, he began the interview process by informing the students of the importance that they be honest in their responses. Explaining, that researchers were only interested in their experiences, thoughts and feelings from the ROV course and competition.
3. The students were told that the conversation would be recorded for the purpose of having accurate records to analyze.
4. The first inquiry made to the students was the following statement:
    a. *I am going to tell you to do something and I want you to think about it for thirty seconds before you answer… I want you to tell me about your experience in the ROV program.*

    This question was intended to be initially vague for the purpose of testing how much students were willing to speak up. While students were thinking about their experience, the interviewer posed a few questions to assist their thought process. The questions were as follows:

    b. *Think back before the ROV program started. What were you expecting the program to be like?*
    c. *Was building the ROV easier than you thought it would be, or was it more difficult?*

   d. *Are you more interested in doing things like you did in the program now, or are you less interested than you were before?*

5. Once thirty seconds had ended, students were more than willing to share their thoughts. The interviewer encouraged them to share stories and experiences relating to how and if the program had an impact on their interest and perception technology and engineering.
   a. Additional questions were addressed in a similar format as the initial inquiry. Below are few examples of the inquiry:
      i. *Tell me about your thoughts before and after the ROV program. Has your feelings or interest or understanding of technology and engineering changed after participating in the ROV program?*
      ii. *Before you participated in this project, did you think about working as an engineer? How about someone who works with new technologies? Has your interest changed after participating in the ROV program? Why do you think that was?*
6. Another inquiry approach extracted statements or questions based on student responses from the 3-in-1 survey assessment instrument. The words inside the brackets could be replaced with any particular response from the 3-in-1. An example of this approach looked like this:
   a. *On the recent survey, some students said [they disagreed] that [technology makes everything better]. Were any of your thoughts/experiences similar to this? Please explain why or why not.*

The rest of the interview continued as described in steps 4-6, until the majority, if not all, statements or questions from survey had been addressed or discussed in the interview.

3.5 Data Analysis

The analysis of the data consisted of two parts: 1) Quantitative statistical analysis of the 3-in-1 survey results and 2) Qualitative analysis of the focus group interviews and observations at the annual UUR competition. The quantitative analysis compromised aggregating data in excel, then analyzing the data using JMP Pro 12. The qualitative analysis utilized a constant comparative method informed by an emergent theme analysis.

Aggregation of the 3-in-1 survey results carefully retained the six categories, or factors, initially instituted in the PATT-USA survey. As described before, those categories are 1) [Technology/Engineering] career aspirations. 2) Interest in [technology/engineering]. 3) Consequences of [technology/engineering]. 4) [Technology/Engineering] is difficult. 5) [Technology/Engineering] is for boys and girls. 6) Tediousness towards [technology/engineering]. Categories created in the original UUR STEM survey were also preserved, which separated and categorized questions relating to STEM interest and STEM perception.

Statistical analyses were performed on the 3-in-1 survey responses, specifically the Wilcoxon/Kruskal Wallis test and Dunn's Method for Joint Ranking test. The Kruskal Wallis test is used for non-normal distributions and since the distribution is not known to be normal, the researchers decided to use this test to determine general statistical significance between the means of the control and treatment groups. After analyzing for statistical significance between only the treatment and control groups, any survey question with significant difference was further investigated by controlling for both gender and treatment, using Dunn's Method for Joint Ranking. Dunn's Method for Joint Ranking is a non-parametric test used for multiple comparisons. The following four pairs were used in the analysis: Treatment Male (TM), Treatment Female (TF), Control Male (CM), and Control Female (CF). In each comparison, one pair's mean was subtracted from another. Each of the following four comparisons were analyzed: 1) (CM – CF), 2) (TM – TF), 3) (TF – CF), 4) (TM – CM).

The second part of the analysis utilized a constant comparative method as outlined by Glaser and Strauss (1967), Strauss and Corbin (1990), and Charmaz, (2002) with an emergent theme analysis. The constant comparative goal is to explain how some aspect of the social world 'works' (Glaser & Strauss, 2009) and aligns with the goal of the current research. The purpose of this research is to investigate theories that explain what impact, if any, a 5-month program of building and competing with ROVs, has on student interest in, and perception of, technology and engineering. This constant comparative method outlines specific procedures that deliver results similar to the desired results for the current study, that is, to ensure that the resulting theories emerge from the data and not from preconceived notions or an *a priori* framework (Glaser & Strauss, 2009).

Following the focus group interviews with the selected students from the treatment group, the constant comparative analysis applied the following "open coding" (Strauss & Corbin, 1990) process of breaking down, examining, comparing, conceptualizing, and categorizing data. The following series of steps lead to a constant comparison of the data with other data and emerging concepts:

1. Uncover "action verbs" (Charmaz, 2014) as a means to find codes for emerging themes in the data.
    a. Action wording discerned "line-by-line", specifically, attempting to code every statement (i.e. distinct ideas in the flow of conversation) as described by Rich (Rich, 2012).

    b. Each code that emerges is assigned a corresponding statement number.

2. Utilize memoing during the coding (and over the entire course of analysis) process to note interesting discrepancies, concepts or anomalies.
    a. Memoing means to elaborate on concepts, vocabulary, catch phrases embedded in data, or connections among concepts (Rich, 2012).
3. Classify differing and similar concepts in order to form categories and further understand the concepts involved in the data.
    a. All statements are looked at and then organized into distinct categories, while attempting to use participants' own words whenever possible.
4. Group and categorize classifications into properties and dimensions (Strauss & Corbin, 1990).
    a. Properties: ask, "What are the characteristics of items that fit the category?"
    b. Dimensions: ask, "How much?" "At what level?" Attempting to dig into rich meaningful contexts of participants' experience.
5. Search for patterns where groups of properties align themselves with various dimensions (Strauss & Corbin, 1990).

If applicable, create models and diagrams as a way to reach conclusions and condense explanations of the conclusions.

4 FINDINGS

This chapter includes a reporting and an analysis of the collected data, and outlines the significant findings. The significant findings are: 1) Males were more interested in technology *and* engineering than females, regardless of whether they participated in the UUR ROV program. 2) Male and female students in the UUR program were more interested and had a more positive perception of engineering than those who did not participate in the UUR ROV program. 3) Females in the UUR program reported more interest in engineering careers and activities than females not in the program. 4) Females in the UUR program reported more interest and self-efficacy in science than females not in the program. 5) Males in the UUR program reported more awareness of the positive and negative consequences of technology and engineering than those who did not participate. Although the most significant findings are discussed in detail in this chapter, a complete reporting of the findings are located in Appendices 1, 2 and 3.

Each finding was analyzed statistically using a Wilcoxon/Kruskal Wallis Test, a non-parametric comparison of the mean rank sum of scores and mean composite rank sum of scores. In the case where pairwise comparisons were analyzed, the Dunn Method for Joint Ranking analysis was utilized. The method was used because it provided a nonparametric comparison for all pairs of control/treatment and male/female groups. Finally, focus group interviews were analyzed using a constant comparative process, informed by an emergent theme analysis to break down, examine, compare, conceptualize, and categorize data (Glaser & Strauss, 2009).

Significance, conclusions and inferences from the results described in this chapter may not be applied to all UUR participating students and all ROV programs, because sampling methods, and some of the variables and comparisons within the demographics of the treatment and control groups were not entirely random; therefore, it is difficult to claim causal relationships for findings in this study. For example, students in the control group (N=47) were selected because the primary researcher had close relations with the control school's teachers and administration. However, the control's age demographics (ages 11 – 12) was only similar to 5% of students in the treatment group (N=280), ages 10 - 17. Participants of the UUR program also attended several schools, both public and private, including elementary through high school institutions around Utah and Salt Lake counties. For these reasons, differences, conclusions and inferences of this study predominantly apply to the control and treatment group students.

Nevertheless, the findings are important to the STEM community because they reveal evidence which indicates ROV programs/activities do impact female interest and perception of technology and engineering. Also, because there are shortages of empirical data regarding the impact ROV programs have on interest and perception of technology and engineering, the findings may help improve and evaluate UUR type programs and STEM related activities. With a more concentrated investigation, significant findings in this study can potentially be inferred upon a majority of applicable ROV programs and their participants.

The following sections discuss the significant findings relevant to the research. Section 4.1 discusses the analysis of the PATT (technology) and PATE (engineering) assessments controlling for the treatment variable using three categories: 1) the composite scores from all treatment and control observations, 2) each PATT and PATE categorical composite scores, and 3) Individual statement scores. Section 4.2 discusses the analysis of the STEM interest and perception assessment, also controlling for the treatment variable. Section 4.3 discusses the analysis of the PATT and PATE assessments controlling for all pairs of gender and treatment variables. Section 4.3 also uses the three categories used in section 4.1. Section 4.4 discusses the analysis of the STEM interest and perception analyses, also controlling for all pairs of gender and treatment groups. Findings from the focus group interview constant comparative analysis are included at the end of each of the sections to help triangulate statistical findings.

4.1 Impact of the UUR Program: Controlling for Treatment

These findings represent how much the treatment and control groups agree or disagree with each statement on a scale of 1-5, where 1=Strongly Disagree, 2= Disagree, 3=Neither Agree nor Disagree, 4=Agree, and 5=Strongly Agree. The first Wilcoxon test analyzed the Treatment and Control's composite mean rank scores of each PATT and PATE assessments. The STEM questions are described separate from this analysis because of the difference in Likert scale values from the PATT and PATE Likert scale values. The analysis of the composite scores for each PATT and PATE assessment were analyzed at alpha .05.

4.1.1 Composite Score for all PATT Statements and PATE Statements

Table 4-1: Composite Score of All PATT and PATE Statements

PATT and PATE Assessments	Prob > Z	Mean Score Difference (T – C)
Composite score of PATT assessment (Treatment – Control)	.9696	162.58 – 161.99 = .59
Composite score of PATE assessment (Treatment – Control)	.6777	163.36 – 157.03 = 6.33

As shown in Table 4-1, the Wilcoxon/Kruskal Wallis test for the composite score of all PATT statements yielded no significant effect. This suggests there was no significant difference between treatment and control scores over the entire PATT assessment. A similar result was found for the composite PATE responses. Although both treatment groups' PATT and PATE mean scores were higher on average than the control, the difference in mean scores was not found to be significant. This finding suggests that quantifying each assessment as one whole composite score, is not very effective in determining differences between treatment and control students' interest and perception of technology (PATT) and engineering (PATE) because there is no reported significant difference in mean scores. This may be because within each PATT and PATE assessment there exist different categories which contain several very different statements where students may agree in one category and the same students disagree in another, thus annulling any significance within specific categories or individual statements. Because of this equivocality, the researchers further analyzed each category in both the PATT and PATE assessments, as well as the individual statements in each assessment. The following section, 4.1.2 discusses the further disaggregation while specifically controlling for the treatment.

4.1.2 Composite Score of Each PATT and PATE Category

The following findings are the Wilcoxon/Kruskal Wallis test for the composite score for each PATT and PATE category; each category is made up of 3-5 statements. As shown in Table 4-2, there are six categories in each PATT and PATE assessment. The statistically significant results in this section came from the following two categories: 1) *Consequences of technology* and 2) *Technology is for boys and girls*. Table 4-3 shows the results from the Wilcoxon/Kruskal

Wallis test for this section. There were no other significant findings in this category. See Appendix 2 for further results within this section.

Table 4-2: PATT and PATE Categories

PATT Assessment Categories	PATE Assessment Categories
Technological career aspirations	Engineering career aspirations
Interest in technology	Interest in engineering
Consequences of technology	Consequences of engineering
Technology is difficult	Engineering is difficult
Technology is for boys and girls	Engineering is for boys and girls
Tediousness towards technology	Tediousness towards engineering

Table 4-3: Composite PATT Categorical Score Controlling for Treatment

PATT Categories	Prob > Z	Mean Score Difference (T – C)
Consequences of technology	.0387	-31.23
Technology is for boys and girls	.0389	30.10

Statistically significant findings from the PATT *Consequences of technology* category suggest that on average, those in the control group agree more than those in the treatment group with the statements in this category. On average those in the control group scored 31 points higher in this category than those in the treatment group. As shown in Table 3-2, these statements relate to the importance and need for technology, thus indicating that the UUR program indeed may have an impact on the treatment in this category. These results could be due to many factors. One possible factor could be because within the UUR curriculum both good and bad consequences of the use of technology is a point of discussion. Discussions on the good and bad use of technology may broaden the understanding and help make students more aware of the good and bad uses of technology beyond the consumption of electronic devices, which is most commonly experienced by the sample size age group of 11-17 year olds. As a result, the treatment group may have responded to this category as a result of being taught the possible positive and negative uses of technology, whereas students in the control group would not have received this instruction.

Findings from the T*echnology is for boys and girls* category show that on average those in the treatment group agree more than those in the control group that boys are better at "technology" related things than girls. This result is not surprising, considering the trends that have been found in previous studies done by de Vries. While at the same time, the researchers of this study were a little disappointed that the difference was not greater in favor of the girls' positive response to their own perception and interest in technology. Of course there are many factors that could not be taken into consideration for reasons why boys scored significantly higher than girls. One of the major factors could be the perception of the general workforce and parental ideologies. Meaning, working with your hands and using tools to build things have been historically done by males, so the females in the UUR program may have let the males do most the work and were consequently perceived as not as capable as males in completing the activity. Even though the girls in the UUR program demonstrated capabilities of not only participating, but also suggesting good ideas, building the ROV and solving problems, the stereotype that "boys do technology" and "girls do homemaking" may be too strong to overcome in this one activity.

Similar to the PATT findings, significant findings from the PATE assessment came from the categories of *Consequences of engineering* and *Engineering is for boys and girls.* Findings from the *Consequences of engineering* category suggest that the perception of the control group tends to agree more than the treatment group that engineering is needed and an important aspect of life. See Table 4-4. Since the results were so similar to the same category in the PATT assessment, the researchers assumed the same reasons for the result in this PATE category.

Table 4-4: Composite PATE Categorical Score

PATE Categories	Prob > Z	Mean Score Difference (T – C)
Consequences of engineering	.0413	-30.85
Engineering is for boys and girls	.1007	24.26

Findings from the composite score for the category *Engineering is for boys and girls* were technically not significant at alpha .05, which intrigued further interest in to why it was not statistically significant in the PATE as it was in the PATT assessment. After further investigation it was concluded that because the control group's average score increased by 5 points from the PATT to the PATE assessment, the common perception that boys are better at doing engineering than girls may be evident in this category as in studies done by similar research. This result also provides insight into 11-17-year-old students' understanding of the distinction between technology and engineering as it relates to boys' and girls' capabilities in, and perception of, technology and engineering. It should be noted also that the treatment group's average score in this category remained practically the same between the PATT and PATE assessments. This constant average score suggests that the UUR program may not effect perception of girls' capabilities in, and perception of, technology *and* engineering, at least when using these assessments.

4.1.3 Constant Comparative Analysis Triangulating Findings from the Composite PATT and PATE Categorical Scores Controlling for Treatment

The constant comparative analysis of focus group interviews revealed three major classifications: 1) *Influence of the design process*, 2) *Reasons for not being interested in technology and engineering*, and 3) *Participants improved awareness and perception of technology and engineering*. Each major classification was informed by an emerging theme analysis, which revealed several sub-categories. Each sub-category was informed by an open coding process (Strauss & Corbin, 1990) beginning with the coding of "action verbs" (Charmaz, 2014) referred to in the previous chapter. A report of these findings can be seen in Table 4-7, 4-8 and 4-9.

Triangulation validates findings from the PATT and PATE categories *Technology/Engineering is for boys and girls* and remains constant throughout this study's findings for these categories. Findings lead to the major classification labeled *Reasons for not being interested in technology*, which is informed by emergent thematic sub-categories labeled a) although the participant had a positive experience, they are still not interested, and b) not interested-haven't ever really been interested (see Table 4-8). These sub-categories emerged from 5 of the 9 focus group interviews. Examples of female statements include:

- "I like technology, but I got less interested in technology and engineering because of my group."

- “If I had to do engineering I would…I would choose the best one and most fun to do. But I definitely want to do something else, although it (engineering) makes more sense, it is still not my thing.”

- “[The ROV program] turned out to be not as bad as I thought–I am just not as interested in this stuff.”

- “I wouldn’t want to do this as a career, but I could do this occasionally…I am clumsy at this kind of stuff.”

This finding is important because it provides insight into the comparison between the treatment group’s constant average score between the PATT and PATE assessments, suggesting that the UUR program may not effect perception of girls’ capabilities in, and knowledge of, technology *and* engineering.

That being said, triangulation also revealed findings that lead to the major classification labeled *Influence of the design process*. This classification emerged from each of the 9 focus group interviews and revealed a property relating to females’ exclusive change of interest in engineering careers or activities. Within this property, evidence of females’ interest in engineering informed the following sub-categories: a) first time doing a ROV program, b) desire to learn more, c) seeing – learning – then doing, d) success or failure through trial and error, and e) confidence boost (see Table 4-7). Female responses that support these sub-categories include:

- “I am more interested now because I got to see how you actually build an ROV and the process it takes. Building the ROV is what made the program more interesting to me.”

- “The program helped me understand the perspective of how things work. You really have to be detailed. It was cool that we got to make it (the ROV).”

- “It was cool because I didn’t know how to make something move like that. I liked being an engineer. It’s something I have never done before.”

- "It was cool that we got to make it (the ROV). It started out just as pipes, by the end of the week you saw it progress into a robot. It felt good to say, 'ya, I built and wired and constructed that robot, and it worked successfully!'"

Both PATT and PATE statistical findings in the *Technology/Engineering is for boys and girls* category, show that the UUR program may not effect perception of girls' capabilities in, and knowledge of, technology *and* engineering. However, the constant comparative analysis suggests that within the classification labeled *Influence of the design process,* there is qualitative evidence that the UUR program impacts females' interest in engineering careers and activities. Interestingly, it's worth noting that the winners for the overall UUR competition over the past two years have been female.

4.1.4 Individual PATT and PATE Statements

The following section reveals only the significant findings of each individual PATT and PATE statement controlling for the treatment variable. See Table 4-5 for a display of the PATT findings and Table 4-6 for the PATE findings. For further results of other individual questions and non-significant results, refer to Appendix 3. For each variable—treatment and control—the sums of the scores from the treatment group were compared to the sums of scores for the control group. The control group scores were subtracted from the treatment group scores.

Table 4-5: Individual Statements from the PATT Assessment

PATT Statements	Prob > Z	Mean Score Difference (T – C)
A) I would like a career in technology	.0382	30.33
B) If there was a school club about technology I would certainly join it	.0480	29.19

Table 4-5, Cont'd.

C) Technology makes everything work better	.0035	-42.99
D) Technology is important in life	.0014	-46.93
E) Boys know more about technology than girls do	.0411	29.65
F) Boys are more capable of doing technological jobs than girls	.0171	34.39

Within the PATT assessment, while controlling for treatment, there were six statements significant at alpha .05 including: A) I would like a career in technology, B) If there was a school club about technology I would certainly join it, C) Technology makes everything work better, D) Technology is important in life, E) Boys know more about technology than girls, and F) Boys are more capable of doing technological jobs than girls.

The results of statement A show that those who participated in the UUR program, agree significantly more than the control group, that they would like a career in technology. In other words, students in the program reported more interest for technological career aspirations than those who were part of the control group.

The results from statement B reveal that participants of the ROV program scored 29 pts. higher than those of the control group. This suggests that those who participated in the ROV program are more interested in joining an after school club about technology than those who were in the control group.

Triangulation from the constant comparative analysis validates findings in statements A and B. Findings suggest that the UUR program influenced students to think more about how technology works and their increased desire to work with technology (see Table 4-7). The evidence leads to the major classification *Influence of the design process*, which was informed by the emergent sub-category a) desire to learn more, found in 8 of the 9 interview episodes. Examples of supporting responses came from focus group students reflecting upon how the UUR program influenced their thoughts about statements A and B in Table 4-5:

- "…during the building [of the ROV], it seemed to really help me understand more about technology and the oil industry and explain oceanography with the ROVs and how they do that."

- "I would like to be a new technology designer. I was interested before, but the ROV experience made me want to do more inventions."

- "My mind was more set on sports [before the UUR program] and stuff, but after I did it [UUR] I thought, 'Oh! I should be a mechanic!"

- "I would join in [an after school technology program] because you get to make things or rebuild things you never thought you could actually do."

Results for statements C and D suggest a negative statistical relationship; meaning average scores in the control group were greater than the treatment. Results from statement C show that the control group agrees significantly more, on average, that technology makes everything work better than those who participated in the ROV program. Those in the control group scored 42 points higher than participants of the ROV program.

Similar to statement C, the statistical relationship between treatment and control for statement D was negative. The results show that students in the control group agree more frequently that technology is important in life, than compared to those of the treatment group. The control group scored 46 points higher than those of the treatment group. In other words, results from statement C and D, suggest that the ROV program may have a strong impact on students' perspective of the consequences of technology when compared to the control group.

Further investigation reveals that the statistical negative relationships found in statements C and D indicate participants' deeper understanding and increased awareness of the positive and negative uses of technology. The constant comparative analysis provides more insight into these findings.

The constant comparative analysis of the focus group interviews suggests that most students understand that technology is important in life, but realize that there are positive and negative consequences of technology. Evidence was found in each of the 9 interviews and lead to the emergent classification, *Participants improved awareness and perception of technology and engineering*, informed by the sub-category labeled, a) what was learned about technology and engineering-related content or careers (see Table 4-9). Supporting examples from student responses include:

- "I think we can improve the technology already built, to the highest it can go, but still leave room so that everything isn't done for us, so that we can still do things for ourselves."
- "After being burned with the soldering iron, I wasn't liking the idea of the program."
- "Technology is good but as long as it still allows us to do things ourselves. Otherwise we'll all end up like the movie Wall-E with all the fat people in chairs."
- "I think we definitely need engineering, but we don't need ALL the technology…like phones can be good and bad."
- "[The ROV] program made me less interested because it was stressful. I got burned quite a few times and I actually lost sleep over it all a few times."
- "I think there are some things about it (technology) that we really need it in our society to just make the world a better place…But then again, it would be kind of dangerous because if people had robots work for them etc. then people could get away with bad things."

Results for statements E and F show a typical trend found in the review of literature between girls' and boys' perspectives of the technology field. Participants of the ROV program agree 29 points higher than those in the control group, that boys know more about technology than girls. On average, ROV participants also agree 34 points higher than the control group, that boys are more capable of doing technology-related jobs than girls. These results suggest that the ROV program may not have a strong impact on the traditional perspective that "boys are better with technology" and "girls are not very good with technology" when compared to the control group.

Within the PATE assessment, there were five individual statements significant at alpha .05: A) I will probably get a job in engineering later on. B) If there were a school club about engineering, I would certainly join it. C) Engineering makes everything work better. D) Engineering is important in. E) Boys are more capable of doing engineering jobs than girls. See Table 4-6 for a display of these results.

Table 4-6: Individual Statements from the PATE Assessment

PATE Statements	Prob > Z	Mean Score Difference (T – C)
A) I will probably get a job in engineering later on	.0105	37.46
B) If there was a school club about engineering I would certainly join it	.0114	37.43
C) Engineering makes everything work better	.0025	-44.58
D) Engineering is important in life	.0006	-49.87
E) Boys are more capable of doing engineering jobs than girls	.1226	22.36

The above findings suggest that the treatment group scores 37 points higher than the control group when rating statements, A and B. In other words, participants of the ROV program, on average, indicate more consideration of getting an engineering career later on and more interest in joining engineering clubs, than those who were not in the ROV program.

As in the PATT findings, triangulation of the constant comparative analysis provides more insight and support for findings in statements A and B. Findings suggest that participants expressed "sparked" and increased interest in engineering careers and activities. Supporting evidence emerged from each of the 9 interviews and lead to the emergent classification, *Influence of the design process*, informed by sub-categories a) seeing – learning – doing and b) desire to learn more. Evidence through student responses includes:

- "I want to be an airplane engineer…when I grow up I want to be somebody who engineers the controls. It (UUR) sparked more interest in me and gave me confidence [to do] the soldering and stuff."

- "Not only was I more interested, I also had a little more knowledge with the soldering and the techy stuff. Now I'm signing up for the robotics class next year in jr. high. I want to go into orthodontics, but I'm also now very interested in engineering."

- "I always thought of engineering as a job where you don't get paid very much and kind of boring…So I always thought I'd do more fun jobs. But after researching and doing the [ROV] program, you learn that it is really fun."

- "What made me more interested in learning how things work is when my group was soldering the wires, I started thinking, "well this wire goes here", so it started making me think about what happens – like what makes it go and everything. I hadn't really thought about what makes things work before this [ROV] experience."

- "I wish we could make a bigger machine so there would be more parts that we could learn about. That would make it even more interesting."

In statements C and D, the control group scored significantly higher than the treatment group. In other words, for the students who participated in the control group, results show that they agree on average 46.5 points more than those in the treatment group when asked these statements. One might anticipate that if students participated in this ROV program, the result from these categories might be reversed when compared to students who did not participate in the program. However, these findings are consistent with findings from the previous PATT assessment analysis. Explanation of possible reasons for these results is assumed to be similar as in the PATT analysis.

Statement E is included in this report because of the difference of significance from the PATT to the PATE analysis. This same statement was significant in the PATT analysis (statement F in Table 4-5), whereas it is not in the PATE analysis. This change in significance from the PATT to the PATE, may indicate that the students in the ROV program are made more aware of the distinction between technology and engineering, as well as how girls' capabilities are perceived doing and participating in engineering activities. Those who participated in the UUR program may have improved their understanding and distinction of general engineering concepts for girls doing *engineering* activities, than their understanding and distinction of general technology and girls doing *technology-related* activities.

The constant comparative analysis provides more insight into this finding from statement E and validates findings from the review of literature stating participants' level of engagement influenced their level of achievement. Findings suggest that female students more frequently express their level of engagement, understanding and enjoyment related to engineering content and careers than technology content and careers. Supporting evidence emerged from 7 of the 9 interviews and lead to the emergent classifications *Participants improved awareness and* *perception of technology and engineering* and *Influence of the design process*, informed by the sub-categories, a) what was learned about technology and engineering related content and careers, b) first time doing a ROV program, desire to learn more, and c) confidence boost . Supporting evidence includes the following statements from students:

- "When we were doing the ROV program, I definitely have a lot more appreciation for engineering because we just built this tiny robot that could just do some simple tasks; so for what engineers do, which is more complex, it would take a lot more time. This [building the ROV] took months for us so I definitely have a lot more appreciation for them."

- "I always thought of engineering as a job where you don't get paid very much and it's kind of boring-all you do is build bridges and stuff. But after researching and doing all this (building the ROV) you learn that it's really fun."

- "It (UUR) really helped me to do a lot more stuff. Because like I said, I hadn't really had any experience with engineering before this. It helped me know more about engineering and what it is and what things they make."

- "When we first started I was kind of nervous because I was worried about doing everything wrong. I thought engineering would be much harder that it really was. It (making the ROV) ended up being pretty easy and I enjoyed it much more than I thought I would. I just thought it was really cool."

- "It's (engineering) super worth the work in the end, even with all the mistakes…But I think all engineers have mistakes like that. But in the end they make some of the most useful inventions. In order to get something really useful, you might make some mistakes. But it's worth it."

Table 4-7: Major Classification: Influence of the Design Process

Label (action verbs)	Sub-Category	Property	Dimension
(1-girl 6:00) "I am probably more interested now that I know how it works. I have never built a robot before."	First time doing a ROV program.	Interest in T and E positively changed	Knowledge and experience through doing (making) new things
(9-boy 10:35) "I thought it was really cool because I've never really done a lot with engineering before- I've built tree houses and stuff, but I haven't built anything that would be underwater and motorized. I think the stuff they used to make it would be very useful in the future, if I'm going to ever make something underwater. I think it (the ROV program) would help a lot for anyone who does an engineering job."			
(1-girl 1:48) "It was cool because I didn't know how to make something move… I liked being an engineer. It's something I have never done before"			
(2-girl 2:05) "Before, I wasn't really excited, but after we started building and it came to competition I got more excited. Building it was really fun and exciting, because I've never done something like this before."			
(8-boy 13:53) "I was [*more interested*] because it's fun using power tools and stuff… I was more excited because I've never done something like that before."			
(2-girl 9:13) "I probably would *[take an engineering class]* because I just like creating things and seeing after your work is done what you did. This experience helped me realize that more, because at first I didn't think I liked engineering, but after I did it I realized it was really fun!"	Desire to learn more		
(2-girl 13:45) "I want to take a couple engineering courses because of the ROV experience."			

Table 4-7, Cont'd.

(9-boy 5:26) "I would want to do it (the ROV program) again because of all the fun things that come from it, you learn more and you see how stuff works." *(8-girl 5:24)* "I would say that now I really want to do more with engineering and to be in different programs that would help me to have more experience in building robotics and stuff like that." *(Interviewer): 'Have you ever been interested in this stuff before?'* "I've watched my dad do stuff since he's a construction worker etc. but I haven't ever really done anything like this." *(9-boy 1:17)* "I liked it because as soon as I found it was a water competition and they (ROV's) were used for ocean research I was interested to learn almost anything about that. Because even today I'm still trying to do my best to research the ocean. One of the careers I want to do when I grow up is eventually build submarines that go really deep under water." *(3-girl 3:15)* "After everything was done, I thought about possibility of becoming an engineer. I liked it." *(9-girl 5:08)* "I would probably want to join another group because I think it's really cool how things work and how they're put together. It's interesting."			
(3-girl 5:10) "What made me more interested in about how things work is when my group was soldering the wires I started thinking 'Well, this wire goes here,' so it started making me think about what happens- like what makes it go and everything. I hadn't really thought about what makes things work before this experience. I just thought they did and that's how it was."	Seeing – learning – doing.		

Table 4-7, Cont'd.

(2-boy 1:28) "My interest in engineering changed because, as soon as we got in the pool I looked from a different angle and realized the different ways that we should have planned in the beginning of what we were going to do. If we had done that before we would have had a better strategy." *(10-boy 1:53)* "I'm more interested because it was a lot of fun seeing how the wires and the circuit board etc. seeing how all that works. and that we got to have hands on activities." *(1-girl 5:45)* "I was more interested because I got to see the how you actually build and ROV and the process it takes. Building the ROV is what made the program more interesting." *(1-girl 2:23) [The ROV program]* helped you understand the perspective of how things work; you really have to be detailed. It was cool that we got to make it.			
(3-boy 1:03) "Before the program I didn't know much about technology and I wasn't expecting the competition to have so many schools in it. It was totally fun!_And we totally failed! But it was still a lot of fun. I've found with engineering that things aren't always what they seem. Also, technology seems much more appealing to me now (because of the program). Because we learned about all this cool stuff, like learning how to wire, and now I know lots of short cuts. *(3-boy 4:47)* "When my partner and I had to retrieve this box, I was driving but I couldn't get it up and I thought maybe if we put a second middle motor in (because we only had one and it wasn't enough power) if it would help." *(7-girl 3:40)* "I lost a lot of interest because we had a lot of problem but I was interested in the circuit board and how it worked. I hadn't really thought of working in electronics or anything before this."	Success or failure through trial and error		

Table 4-7, Cont'd.

(8-girl 1:18) "Yes it also interested me to do more with technology, robotics and stuff like that. I liked working with the circuit boards and soldering the wires to them, figuring out how to work with our problems. My group had a lot of problems with soldering wires." *(8-boy 6:11)* "I would want to do more of this because it's challenging and you are a solving problems and try to get better." *(9-girl 11:27) "*I think a job in technology would be really difficult because you have to build, solder and learn how to drive it and you'd either need to be prepared first hand, or have instructions on how to do it, and go through it multiple times to see if it works/does not work. Once you do it you'll end up liking it and then you'll be proud of it. So i think it would be really difficult but also fun."			
(1-girl 12:15) "Even though we messed up a ton on our ROV, I thought I don't want to do this as a career. When we got second, I thought, I'm kinda good at this, it would be fun to do something like that (build things like ROVs)." *(8-girl 3:14)* "I felt very accomplished at the competition because I did all of that (made an ROV work). Even during the working on it, looking back on all of the things we had done, it was a very big accomplishment." *(3-girl 0:35)* "I feel like I can do more technology now because of the program. I liked it, so I want to do more." *(5-boy 1:11)* "Before we started I didn't think this was going to be very fun because it didn't seem very fun, and then by the end (at the competition) I was thinking I want to do this more because I felt like I was AWESOME at it! Because we would get the rings on it, we got the door open, we just felt very confident."	Confidence boost		

Table 4-7, Cont'd.

(8-boy 10:48) "It was exciting already, but when I got to the competition and I saw what we had to do I said "wow this is hard" but we still made it through and the first challenge that we completed I felt like "we got this!" because it only took us like 1 min. It was really interesting." *(9-boy 19:47)* "I thought it was going to be really cool at first, so when we started doing it I was getting so excited because it would be so cool. But then it was even more fun because when we actually used it in the water it was like getting a birthday present that you've kept in storage for like 3 years! Wahoo! Let's do this- this is so cool!"			
(1-girl 13:53) "The program changed my mind in a positive way because I always knew I wanted to be some kind of engineer. I thought it (the ROV program) was cool because I could do hands-on stuff." *(7-boy 4:20)* "I want to be an airplane engineer and all the electronic stuff kind of fascinates me and when I grow up I want to be somebody who engineers the controls and it (UUR) sparked more interest in me and gave me confidence in soldering and stuff." *(9-boy 7:15)* "I want to be just like my dad. My dad is a computer scientist and he works with robotics and stuff like that all the time; so eventually if I'm going to do that, then I need to learn." *(8-boy 14:39)* "When I grow up I want to be a pilot so I knew you had to do these things, and this kinda gave me a view of 'ok this (doing the ROV challenges at the competition) is something I might have to do in order to pass a test.'" *(10-boy 4:44)* "I've always wanted to be a pro-athlete, but I have also wanted to be a robotic engineer and this ROV experience added onto that even more because it was a fun experience."	I always knew I would do something with technology or engineering	Interest didn't change much	Interest in engineering stems from an unknown phenomenon (innate, influence at home etc)

Table 4-8: Major Classification: Reasons for not Being Interested in Technology and Engineering

Label (action verbs)	Classification	Property	Dimension
(2-girl 5:20) "It was a great experience but I probably won't become an engineer, but it was really fun creating something that actually worked." *(2-girl 5:02)* "I think it was a fun experience, but I don't think I'll become an engineer just because I like to do other stuff, but it definitely was fun, I still want to build stuff." *(1-girl 3:45)* "If I had to do engineering I would...I would choose the best one and most fun to do. But I definitely want to do something else, although it makes sense now, it is still not my thing." *(1-girl 1:40)* "Turned out to be not as bad as I thought. I am just not as interested in this."	Student may have had a good experience, but they are still not interested	Personal or group-related reasons negatively impact interest.	Not interested in technology nor engineering
(1-girl 10:44) "I like technology - but I got less interested in technology and engineering because of my group." *(10-girl 1:14)* "It actually made me less interested because it was stressful. For example, I got burned quite a few times, and I actually lost sleep over it all a few times." *(10-girl 8:33)* "Even though I did all the research and tried to do it (build stuff), I found myself watching my team do it all, because whenever I tried to do any of it I would just mess it up and we'd have to start over. So I'm not sure if I would want any more experience with the actually engineering part of it." *(7-girl 5:38)* "I've never really had an interest in engineering and this didn't make me want to do engineering because we ran into a lot of problems and we had to fix them and they took a long time."	Had a bad experience. Not interested		

Table 4-9: Major Classification: Participants Improved Awareness and Perception of Technology and Engineering

Label (action verbs)	Classification	Property	Dimension
(2-boy 00:55) "When we watched what you did with your ROV when you built it, it looked pretty easy, but then when we did it, it was harder. You have to put a lot of work towards engineering." *(1-girl 6:11)* "I have mixed emotions. I wasn't expecting it to be as hard as it was. I didn't know that if one little thing didn't work, the whole thing wouldn't work." *(4-girl 10:25)* "During the competition, we couldn't go up or down- so we had to just sit there for a couple hours. Then before the competition one of our propellers broke and it wouldn't work so we had to do it all over again." *(4-girl 3:58)* "I kind of always wanted to be an engineer and build a "shrink ray" and stuff but it's just so hard. The ROV experience was harder than I thought it would be."	Difficulty of program was higher or lower than expected	Preconceived understanding of the difficulty of UUR was incorrect	Perception of ROVs and UUR
(3-boy 5:57) "I used to just assume that technology just does what it does and had no question about it. But now whenever I see something that is 'technology' then I just think it my mind 'How does it work?' and I try to figure it out. I'll tear it apart and see if I was right. I would not have done that before I joined the ROV program. DEFINITELY not." *(1-boy 7:58)* "Before, I thought technology was boring; it was about making devices (manufacturing them). Technology is more complicated than I thought *(10-girl 11:09)* "I just want to say that I've never really planned on doing an engineering job, but now that I saw it (UUR) I know that it's a very important job in our society. If we need more people for anything, ya know (it should be for engineering)."	What was learned about technology or engineering related content or careers	Understanding of technology and engineering content or related careers.	Understanding or perception of technology and engineering

Table 4-9, Cont'd

(7-boy 15:33) "The teacher talked to us about that there is a big call (need) for people in the technology stuff (workforce) and yet there is a need for people in construction, there is a shortage there as well as the coal mining industry and power etc. More people are going towards technology. So I think it (technology) can be good and bad."			
(2-Boy 13:10) "Technology is good, but as long as it still allows us to do things ourselves- otherwise we'll all end up like the movie "Wall-E with all the fat people in the chairs."			
(3-boy 4:05) "During the building *[of the ROV]* it seemed to really help me understand more about technology and the oil industry, and explain oceanography with the ROVs and how they do that. Also during the competition, when we saw all the posters."			
(9-girl 12:50) "When we were doing the ROV program I definitely have a lot more appreciation for engineers because we just built this tiny robot that could just do some simple tasks; so for what engineers do which is more complex, it would take a lot more time. This (the ROV) took months for us so I definitely have a lot more appreciation for them."			
(7-boy 14:38) "At the very beginning of the whole ROV experience, like clear back in September, she (the teacher) had a PowerPoint that explained the reason why we're doing this is because of the technological race across different states – so our state is trying to be the most educated and get the best people so we can thrive in it. Which I think is good and bad since we're competing against each other."			
(10-Boy 12:02) "I think there are some things about it that we really need it in our society to just make the world a better place, like better vehicles, technologies, and to discover new things. But then again, as our teacher said, it would be kind of dangerous because if people had robots work for them etc. then people could get away with bad things."			

Table 4-9, Cont'd

(5-girl 4:18) "I always thought of engineering as a job where you don't get paid very much and kind of boring. All you do is build bridges and stuff. So I always thought more about the other fun jobs. BUT after researching it and doing all this (build an ROV in UUR) you learn that it's fun."			

4.2 Impact of the UUR Program: STEM Interest and Perception

The original UUR survey assessment is categorized in this research as the "STEM" questions because they include math and science, as well as engineering topics. There were no composite *STEM interest* comparisons because each particular *STEM interest* question was measured on a unique Likert "agree" scale. The following scores were analyzed in the following three categories: A) Individual STEM Interest B) STEM Perception and C) Composite STEM Perception. The latter category is the sum of all STEM perception scores from the treatment group compared to the sum of all the scores from the control group. See Appendix 3 for all results. Table 4-10 displays the individual questions within each category.

Table 4-10: Individual Questions Found in Each STEM Category

Category A: Individual STEM Interest	**Category B: STEM Perception Scores**	**Category C: Composite Perception Score**
How much do you like Math? How much do you like Science? Rate how good you are at Math Rate how good you are at Science I like to find out how things work I would like to be an Engineer some day I would like to take a class about engineering	An engineer uses science to build new and useful things The world has enough engineers I am good at math I am good at science I am good at inventing things I am very creative It's hard to find an engineering job The most important thing about a job is how much money you make	Sum of all treatment mean scores and sum of all control mean scores from category B compared to each other. The control's mean score is subtracted from the treatment's mean score.

4.2.1 Individual STEM Interest Questions

There were two significant findings within the individual STEM interest questions while controlling for treatment and control. As shown in Table 4-11, the following two assessment items were significant at alpha .05: 1) How much do you like science? and 2) Rate how good you are at science. These two results suggest that those in the UUR program, on average, express interest and positive self-efficacy significantly more than those in the control group. It is important to note possible factors that may be at play within these two findings. For instance, it was known that many of the teachers who volunteered to participate in the UUR program were science teachers, thus unintentionally or intentionally influencing their students' interest and self-efficacy in science. Also, the curriculum included more science concepts than math, such as observation, prediction, discovery, propulsion and buoyance, thus giving students more opportunities to have positive experiences with science rather than math.

Table 4-11: STEM Interest Survey Questions

STEM interest question	Prob > Z	Mean Score Difference (T – C)
How much do you like science?	.0120	36.06
Rate how good you are at science?	.0076	38.62

Findings from this section suggest that students in the UUR program enjoy science more and have more positive self-efficacy in science than those not in the program. This could be because of the nature of the content and hands-on elements the UUR program promotes. Additionally, as was said before, there were a significant amount of science teachers who volunteered to participate in the program, thus possibly influencing their students' interest and self-efficacy in science.

4.2.2 Individual STEM Perception Statements

Results in this category consisted of five significant statements. The following statements were found to be significant at alpha .05: 1) An engineer is someone who uses science to build new and useful things. 2) The world has enough engineers. 3) I am good at science. 4) It is hard to find a job if you become an engineer. 5) The most important thing about getting a job is how much money you make. Table 4-12 displays the analysis of these results.

Table 4-12: STEM Perception Survey Statements

STEM perception statement	Prob > Z	Mean Score Difference (T – C)
An engineer is someone who uses science to build new and useful things	.0407	28.56
The world has enough engineers	.0052	-40.47
I am good at science	.0597	27.25
It is hard to find a job if you become an engineer	.0849	-25.23
The most important thing about getting a job is how much money you make	.0515	-28.69

These results suggest two things about students' perceptions about engineering and engineering careers. First, students participating in the UUR program demonstrate more awareness of the need for more engineers than those in the control group. Statistical evidence reports students in the control scored an average of 40 points more than the treatment when asked how much they agree with the statement “the world has enough engineers.” This finding is important because it suggests that students’ understanding and perception of engineers improved through the UUR program. Second, students in the UUR program report a better understanding of what engineers do than those not in the program. UUR participants scored an average of 29 points more than the control when asked whether or not they agree that engineers use science to build new and useful things. It is possible that because the UUR participants experience and learn about engineering and science while building an ROV in the UUR program, their perception of what engineers do changes to have a more accurate understanding of the practicality and purpose of engineers.

4.2.3 Composite STEM Perception

The results for this category were not significant at alpha .05. This finding suggests that as a whole, when considering all scores for each item in the STEM perception category that neither the treatment nor the control’s responses were significantly different from each other.

4.3 Impact of the UUR Program: Controlling for Gender and Treatment

The following sections used the Wilcoxon test and constant comparative qualitative analysis consistent with previous analyses in this study. This section however, looks deeper into the previous analysis by controlling for gender. The reason for performing this analysis in addition to the analysis controlling only for treatment is because gender has traditionally been a major factor in interest and perception of technology and engineering. If this study is to analyze the impact the UUR program has on student interest in, and perception of, technology and engineering, then gender is an important variable to control.

To better organize each comparison in the statistical analysis, the researchers labeled the pairs as follows: ControlMale (CM), ControlFemale (CF), TreatmentMale (TM), and TreatmentFemale (TF). All possible groupings were tested in this analysis. The nonparametric comparisons for all pairs using the Dunn Method for joint ranking were used in each of the succeeding sections as follows: [(CM) – (CF)], [(TM) – (CF)], [(TF) – (CF)], [(TM) – (TF)], [(TM) – (CM)], and [(TF) – (CM)]. It should be noted that the comparisons between the TreatmentFemale (TF) and ControlMale (CM), as well as the TreatmentMale (TM) and ControlFemale (CF) pairs were trivial for the purposes of this study and were consequently taken out of all reports for this research.

4.3.1 Composite Score for the PATT and PATE Assessment

The findings are comprised of the full PATT assessment composite score while controlling for the gender and treatment variables. This means that each UUR participant's response to the entire PATT assessment was added up and averaged. That averaged composite score was then compared to the averaged composite score for each applicable pair, such that the one was subtracted from the other. The same process was performed for the entire PATE assessment as well. Table 4-13 displays the analysis results for this section. For a full report of the findings, refer to Appendix 2

Table 4-13: Composite PATT and PATE Score

PATT and PATE Assessment	Grouped Pairs and P-values	Mean Score Difference
Composite score of PATT assessment	**(CM – CF) = .0027** **(TM – TF) = .0070** (TM – CM) = .5967 (TF – CF) = 1.000	(CM – CF) = 99.27 (TM – TF) = 36.80 (TM – CM) = -35.78 (TF – CF) = 26.66
Composite score of PATE assessment	**(CM – CF) = .0023** **(TM – TF) = .0222** (TM – CM) = .8187 (TF – CF) = .5917	(CM – CF) = 100.50 (TM – TF) = 32.89 (TM – CM) = -32.34 (TF – CF) = 35.25

The composite scores for the PATT assessment tend to suggest statistical significance within the paired *gender* groups more so than with paired *treatment* groups. For instance, the comparison between the [CM (-) CF], and [TM (-) TF] pairs resulted in a p-value = .0027 and .0070. The [CM (-) CF] group had a score mean difference of 99.27 points and the [TM (-) TF] group had a score mean difference of 36.80 points. In contrast, the comparisons between the [TM (-) CM] group, and the [TF (-) CF] group resulted in p-values = .5967 and 1.000.

According to the composite PATT assessment score while controlling for gender and treatment, these quantitative findings suggest that as a whole, regardless of whether students were in the UUR program, males were more interested in and have a better perception of technology than girls. Evidence is shown in the average male (TM and CM) pairs scoring significantly higher than those pairs including females (TF and CF). Meaning the pairwise comparisons including males tend to agree more on average with the PATT statements than do the female pairwise comparisons. This trend confirms findings in this study's PATT analysis controlling for treatment only, and findings found in the review of literature regarding previous PATT studies.

Similar findings resulted from the PATE assessment analysis. The statistically significant results at alpha .05 were found within the gender variable. Specifically, the comparison between the [CM (-) CF], and [TM (-) TF] pairs resulted in p-values = .0023 and .0222. The [CM (-) CF] group had a score mean difference of 100 points, while the [TM (-) TF] group had a score mean difference of 32.89 points. No significant results at alpha .05 were found exclusively using the treatment variable.

Additionally, and similarly to the PATT results, the composite PATE assessment scores, while controlling for gender and treatment, suggest that as a whole, the UUR program (treatment) did not have as much of an impact on the interest and perception of engineering as did the gender variable. Evidence is shown in the average male (TM and CM) pairs scoring significantly higher than those pairs including females (TF and CF). Meaning the pairs with males tend to agree more with the PATE statements than the pairs with females. This trend confirms that males traditionally have more interest in, and perception of, engineering than females do.

Overall, the statistical results provided by this particular analysis are unclear as it relates to the students' in the UUR program reporting a difference in interest in, and perception of, technology and engineering when compared to those not in the program. A more detailed investigation, including categorical and individual statement analyses are needed to identify specific effects of the UUR program. Such investigations are discussed in the following sections.

4.3.2 Composite PATT and PATE Categorical Scores

The first few paragraphs of this section discuss the Wilcoxon test analysis of the PATT categorical composite scores. Following the PATT categorical analysis, the Wilcoxon test analysis of the PATE categorical composite scores will conclude this section.

This analysis found five categories with statistical or otherwise practical significance from the composite PATT categorical scores while controlling for gender. The significant categories and specific significant paired gender groups include: A) Technological career aspirations; [TM (-) TF]. B) Interest in technology; [CM (-) CF], [TM (-) TF]. C) Consequences of technology; [TM (-) CM]. D) Technology is difficult; [TM (-) TF]. E) Technology is for boys and girls; [CM (-) CF], [TM (-) TF], [TF (-) CF]. Table 4-14 displays the analysis of the composite PATT categorical scores.

Table 4-14: Composite PATT Categorical Scores

PATT Category	Grouped Pairs and P-values	Pair's Mean Score Difference
Technological career aspirations	(CM – CF) = .2591 **(TM – TF) = .0764** (TM – CM) = 1.000 (TF – CF) = 1.000	(CM – CF) = 56.95 (TM – TF) = 28.13 (TM – CM) = -9.79 (TF – CF) = 19.00
Interest in technology	**(CM – CF) = .0258** (TM – TF) = .1558 (TM – CM) = .3455 (TF – CF) = 1.000	(CM – CF) = 80.58 (TM – TF) = 25.20 (TM – CM) = -41.18 (TF – CF) = 14.18
Consequences of technology	(CM – CF) = .1010 (TM – TF) = 1.000 **(TM – CM) = .0206** (TF – CF) = 1.000	(CM – CF) = 67.34 (TM – TF) = 7.52 (TM – CM) = -63.33 (TF – CF) = -3.47
Technology is difficult	(CM – CF) = 1.000 **(TM – TF) = .0522** (TM – CM) = .3816 (TF – CF) = 1.000	(CM – CF) = -16.39 (TM – TF) = 29.60 (TM – CM) = 40.11 (TF – CF) = -5.88
Technology is for boys and girls	**(CM – CF) = .0055** **(TM – TF) = .0066** (TM – CM) = 1.000 **(TF – CF) = .0623**	(CM – CF) = 90.95 (TM – TF) = 35.88 (TM – CM) = -1.97 (TF – CF) = 53.08

Significant findings from the *Technological career aspirations* category suggest that on average, the TreatmentMale pair agrees more than those in the TreatmentFemale pair that they might consider a technological career. On average those in the TreatmentMale pair scored 28 points higher in this category than those in the TreatmentFemale pair. As in findings previous to this category, this finding is consistent with the notion that females in technological careers are a minority.

Significant findings from the *Interest in technology* category, suggest that the ControlMale pair agrees 80 points more than the ControlFemale pair. This result is not surprising. Yet when you consider the pairwise comparisons of the TreatmentMale and TreatmentFemale with the ControlMale and ControlFemale, these results suggest that treatment females reported more interest in technology than control females. In other words, the evidence suggests that males in the control group are significantly more interested in technology than females in the control; however, females' scores in the UUR program were closer to the males' scores in the UUR program. This finding suggests that once females participate in the program, their interest is reported at a level more closely related to those of the males. Considering the analyses of the [TF (-) CF], and [TM (-) CM] paired groups, it is difficult to support this claim because neither pairwise comparison yields statistical significance. Nevertheless, there is qualitative evidence that support the idea regarding females in the program reported more interest in technology *and* engineering as a result of the UUR program. These details are discussed in section 4.3.4 and displayed in Tables 4-7 and 4-9.

Significant findings from the *Consequences of technology* category suggest that the ControlMale pair agrees 63 points more than the TreatmentMale pair when considering the importance and need for technology. The statistical significance of this finding is consistent with the analysis discussed earlier while controlling only for the treatment, but provides more insight as to why the control scored significantly higher than the treatment. That is, that treatment males' report more awareness of the consequences of technology when compared to this control group. Again, supporting qualitative results for this finding are discussed in section 4.3.4 and displayed in Table 4-9.

The category *Technology is for boys and girls,* yielded significant results from three of the four pairwise comparisons, two of which were below the set alpha .05. The composite score analysis suggests that the ControlMale and TreatmentMale pairs agree significantly more with the statements in this category than the ControlFemale and TreatmentFemale pairs. This finding is common among the general male and female population when related to technology. The third finding in this category shows that the TreatmentFemale pair scores significantly higher than the ControlFemale pair. Unless you consider the individual statements that make up this category, this finding could be misleading. This finding indicates that more treatment females reported that boys are better with technology-related things than the control female pair reported.

The following paragraphs discuss the analysis of the PATE categorical composite scores. The composite PATE categorical scores analysis—controlling for gender—found five categories with statistical or practical significance. The significant categories and specific significant paired groups include: A) Engineering career aspirations; [CM (-) CF], [TM (-) TF]. B) Interest in engineering; [CM (-) CF], [TM (-) TF. C) Consequences of engineering; [CM (-) CF], [TM (-) TF], [TM (-) CM]. D) Engineering is difficult; [TM (-) TF]. E) Engineering is for boys and girls; [CM (-) CF], [TM (-) TF]. Table 4-15 displays the analysis of these results.

Table 4-15: Composite PATE Categorical Scores

PATE Category	Grouped Pairs and P-values	Pair's Mean Score Difference
Engineering career aspirations	**(CM – CF) = .0417** (TM – TF) = .6755 (TM – CM) = 1.000 (TF – CF) = .2758	(CM – CF) = 76.03 (TM – TF) = 17.92 (TM – CM) = -15.64 (TF – CF) = 42.45
Interest in engineering	**(CM – CF) = .0461** (TM – TF) = .4112 (TM – CM) = 1.000 (TF – CF) = 1.000	(CM – CF) = 72.25 (TM – TF) = 20.62 (TM – CM) = -25.78 (TF – CF) = 28.83
Consequences of engineering	(CM – CF) = .0681 (TM – TF) = 1.000 **(TM – CM) = .0118** (TF – CF) = 1.000	(CM – CF) = 71.23 (TM – TF) = 2.76 (TM – CM) = -62.92 (TF – CF) = 1.52
Engineering is difficult	(CM – CF) = 1.000 **(TM – TF) = .0499** (TM – CM) = .6730 (TF – CF) = 1.000	(CM – CF) = -14.02 (TM – TF) = 29.77 (TM – CM) = 34.34 (TF – CF) = -9.45
Engineering is for boys and girls	**(CM – CF) = .0143** **(TM – TF) = .0035** (TM – CM) = 1.000 (TF – CF) = .2526	(CM – CF) = 83.51 (TM – TF) = 37.87 (TM – CM) = -3.42 (TF – CF) = 42.19

Significant findings from the *Engineering career aspirations* category suggest that the ControlMale pair agrees 76 points more than the ControlFemale. This means the ControlMale pair would consider an engineering career more than the ControlFemale. This finding continues to validate previous findings throughout this study and others found in the review of literature that males not in the UUR program generally are more interested in engineering than females.

Another finding that has also been consistent throughout this study is found among the treatment male and female analysis. Although this finding is not below alpha .05, it is reported to show practical significance amongst females in the UUR program and their interest in engineering careers, as well as the next category, *Interest in engineering*. This finding suggests that the TreatmentFemale pair within the [(TM – TF)] pairwise comparison reported similar interest in engineering and engineering careers as the TreatmentMale. This also indicates that the females in the treatment male and female pairwise comparison, reported more interest in engineering careers and activities than the females in the control male and female pairwise comparison. The qualitative constant comparative analysis validates these findings and are discussed in further detail in section 4.3.4.

Significant findings from the *Consequences of engineering* category suggest the ControlMale pair agrees 71 points more than the ControlFemale pair when considering all the statements in this category. This finding is consistent with the common assumption that males are more interested in engineering than females. Although, similarly to the previous category's finding, females within the treatment male and female pairwise comparison report a mean score nearly similar to that of the TreatmentMale. Thus suggesting that females in the UUR program perceive similar consequences of engineering as the males in the program. This finding indicates a trend the females in the UUR program continue to report more interest and a better perception of engineering than females in the control.

Additionally, as reported above, there was a consistent statistical significant finding in this PATE category, *Consequences of engineering*, to that of the PATT. That is, the ControlMale scored significantly higher (66 points) than the TreatmentMale. This finding continues the indication that males in the UUR program report more awareness of the consequences of engineering. That being said, the qualitative analysis shows little support of this finding. That is to say males in the focus group responded with accurate and detailed perceptions of the consequences of engineering and its importance in society. This means there may be some misunderstanding or inconsistency between reflection questions in the focus group interview and treatment males' perception or understanding of this category in survey assessment.

The final significant category reported in this section comes from the category titled: *Engineering is for boys and girls.* The findings from this category indicate a strong effect on the gender variable, such that the ControlMale pair tends to agree nearly 83 points more than the ControlFemale. In addition, the TreatmentMale pair agrees 37 points more than the TreatmentFemale pair. These results indicate similar conclusions as previous categories; that regardless of participation in the UUR program, males and females tend to perceive boys as more capable and knowledgeable in general engineering than girls.

4.3.3 Individual PATT and PATE Statement Scores

The following section reveals only the significant findings of each individual PATT and PATE statement controlling for both the gender and treatment variables. The first few paragraphs discuss the findings from the PATT assessment. Following the PATT report, findings from the PATE assessment are discussed.

There were 20 statistically significant or practically significant gender-treatment pairwise comparisons found in the PATT assessment. Many of the following findings are consistent with previous sections; however, this section's findings provide more insight and knowledge by pinpointing specific statements that impact the treatment and gender variables the most. Refer to Table 4-16 to see significant results discussed below.

Table 4-16: Individual PATT Statements

PATT Statement	P-value(s)	Score Difference
1. I would enjoy a job in technology	**(CM – CF) = .0392** **(TM – TF) = .0837** (TM – CM) = 1.000 (TF – CF) = .9976	(CM – CF) = 74.69 (TM – TF) = 27.07 (TM – CM) = -18.89 (TF – CF) = 28.70
2. I would like a career in Technology	(CM – CF) = 1.000 **(TM – TF) = .0270** (TM – CM) = 1.000 (TF – CF) = .9024	(CM – CF) = 60.60 (TM – TF) = 31.01 (TM – CM) = 24.52 (TF – CF) = 29.57
3. If there was a school club about technology I would certainly join it	**(CM – CF) = .0336** **(TM – TF) = .0036** (TM – CM) = 1.000 (TF – CF) = .2131	(CM – CF) = 76.11 (TM – TF) = 37.84 (TM – CM) = 5.32 (TF – CF) = 43.62
4. There should be more education about technology	**(CM – CF) = .0937** (TM – TF) = .4704 (TM – CM) = .3269 (TF – CF) = 1.000	(CM – CF) = 65.56 (TM – TF) = 19.13 (TM – CM) = -40.07 (TF – CF) = 6.33
5. Technology makes everything work better	(CM – CF) = .5657 (TM – TF) = 1.000 (TM – CM) = .0110 (TF – CF) = 1.000	(CM – CF) = 45.86 (TM – TF) = 3.21 (TM – CM) = -65.62 (TF – CF) = -22.93
6. Technology is important in life	(CM – CF) = .3496 (TM – TF) = 1.000 (TM – CM) = .0039 (TF – CF) = 1.000	(CM – CF) = 51.70 (TM – TF) = 5.68 (TM – CM) = -71.56 (TF – CF) = -25.51
7. Everybody needs technology	**(CM – CF) = .0531** (TM – TF) = 1.000 (TM – CM) = .4369 (TF – CF) = .5950	(CM – CF) = 71.84 (TM – TF) = -.16 (TM – CM) = -37.83 (TF – CF) = 34.17
8. You have to be smart to study technology	(CM – CF) = 1.000 **(TM – TF) = .0892** (TM – CM) = 1.000 (TF – CF) = 1.000	(CM – CF) = -23.95 (TM – TF) = 26.77 (TM - CM) = 22.95 (TF – CF) = 7.81
9. To study technology you have to be talented	(CM – CF) = 1.000 **(TM – TF) = .0900** (TM – CM) = .2353 (TF – CF) = 1.000	(CM – CF) = -8.84 (TM – TF) = 26.76 (TM – CM) = 43.47 (TF – CF) = 7.81
10. Boys are able to do practical things better than girls	**(CM – CF) = .0016** **(TM – TF) = .0268** (TM – CM) = 1.000 (TF – CF) = .0662	(CM – CF) = 98.45 (TM – TF) = 30.72 (TM – CM) = -15.98 (TF – CF) = 51.73
11. Boys know more about technology than girls do	**(CM – CF) = .0114** **(TM – TF) = .0067** (TM – CM) = 1.000 (TF – CF) = .0945	(CM – CF) = 83.88 (TM – TF) = 35.29 (TM – CM) = .64 (TF – CF) = 49.27
12. Boys are more capable of doing technological jobs than girls	**(CM – CF) = .0970** **(TM – TF) = .0111** (TM – CM) = 1.000 (TF – CF) = .1428	(CM – CF) = 64.58 (TM – TF) = 33.51 (TM – CM) = 14.72 (TF – CF) = 45.84

Among the results shown above, the major findings come from paired groups where only the gender variable changes in the comparison. For instance, we see that the following statements all have statistically significant differences when comparing either the control male and female pairs, or the treatment male and female pairs: 1) I would enjoy a job in technology, 2) I would like a career in technology, 3) If there was a school club about technology I would certainly join it, 4) There should be more education about technology; everybody needs technology, 5) You have to be smart to study technology, 6) To study technology you have to be talented, 7) Boys are able to do practical things better than girls, 8) Boys know more about technology than girls, and 9) Boys are more capable of doing technological things than girls.

In each of these statements, the male control or treatment pairs scored significantly higher than the girls. This indicates that regardless of participation in the UUR program, males agree more with each statement than females. Accordingly, males in this study reported to be more interested in and have a better perception of technology than females, regardless of their participation in the UUR program.

Besides looking at results of the specific treatment or control male and female comparisons, there were five statistically significant results between the male-specific treatment and control and the female-specific treatment and control pairwise comparisons. These results are indicated by the grey highlighted comparisons in Table 4-13. The discussion of these five findings conclude this analysis using individual PATT statements.

The first finding between male treatment and control suggests that males in the control agree 65 points (p-value .0110) more than males in the treatment with the statement, *Technology makes everything work better.* This finding reports a statistical negative relationship between the treatment and the control regarding the consequences of technology. Triangulation with the focus group analysis further reveals this negative relationship as males in the treatment reporting more awareness of the positive and negative consequences of technology than males in the control. For a more detailed discussion of this finding refer to section 4.3.4.

The third finding between the male treatment and control suggests that the control group agrees 71 points (p-value = .0039) more than the treatment group that *Technology is important in life*. Along with the previous statement's finding, this result indicates a statistical negative relationship among treatment and control. However, as with the previous statement's results, triangulation with the analysis of the focus group interviews reveals males in the treatment reporting more awareness of the positive and negative consequences of technology.

The next two findings come from the female treatment and control pairs, as indicated in Table 4-13. These statements relate to technology being for boys and girls. The analysis indicates that females in the treatment agree significantly more than females in the control that boys are better able to do practical things and know more about technology than girls. Although both of these findings have suggestive significance, because their p-values are greater than alpha .05, the visual comparison with the male treatment and control pairwise comparison indicates that more females in the UUR program than females in the control, report that boys are better capable and more knowledgeable when it comes to technology-related things. Findings suggest that even after experiencing the UUR curriculum and competition, females in the treatment continue the traditional perception that males are better with technology-related things than females. As has been mentioned before, possible explanations could be due to the UUR group dynamics and gender assignments within each team assigned by the teacher. In groups where males and females work together, males may tend to "takeover" responsibilities and technology-related duties, resulting in females not participating or feeling like they aren't capable to contribute. This possible factor as well as other unknown factors leads the researchers to recommend further investigation involving of females' perceptions and experiences within an all-female team within the UUR program.

Findings from the analysis using the PATE individual statements while controlling for gender and treatment include 11 statements with at least one reported statistically significant or practically significant pairwise comparison. Many of the following findings are consistent with the previous analysis using the PATT individual statements; however, this section's findings provide more precise insight and knowledge by pinpointing specific engineering statements that impact the treatment and gender variables the most. Refer to Table 4-17, which displays the significant results discussed below.

Table 4-17: Individual PATE Statements

PATE Statement	P-value(s)	Score Difference
1. I will probably get a job in engineering later on	**(CM – CF) = .0410** (TM – TF) = .3751 (TM – CM) = 1.000 (TF – CF) = .0186	(CM – CF) = 73.70 (TM – TF) = 20.35 (TM – CM) = 7.47 (TF – CF) = 60.87
2. I would enjoy a job in engineering	**(CM – CF) = .0238** (TM – TF) = 1.000 (TM – CM) = 1.000 (TF – CF) = .2517	(CM – CF) = 78.93 (TM – TF) = 11.34 (TM – CM) = -25.48 (TF – CF) = 42.09
3. I would like a career in engineering	**(CM – CF) = .0811** **(TM – TF) = .1074** (TM – CM) = 1.000 (TF – CF) = .2684	(CM – CF) = 67.46 (TM – TF) = 25.93 (TM – CM) = -.10 (TF – CF) = 41.40
4. If there was a school club about engineering I would certainly join it	**(CM – CF) = .0305** (TM – TF) = .2003 (TM – CM) = 1.000 (TF – CF) = .0211	(CM – CF) = 77.12 (TM – TF) = 23.48 (TM – CM) = 6.98 (TF – CF) = 60.66
5. Engineering makes everything work better	(CM – CF) = .5181 (TM – TF) = 1.000 (TM – CM) = .0104 (TF – CF) = 1.000	(CM – CF) = 47.01 (TM – TF) = 7.50 (TM – CM) = -66.00 (TF – CF) = -26.46
6. Engineering is important in life	(CM – CF) = .6917 (TM – TF) = 1.000 (TM – CM) = .0012 (TF – CF) = 1.000	(CM – CF) = 42.87 (TM – TF) = -12.99 (TM – CM) = -77.77 (TF – CF) = -2185

Table 4-17, Cont'd.

7. Everybody needs engineering	**(CM – CF) = .0026** (TM – TF) = 1.000 (TM – CM) = .0906 (TF – CF) = .3102	(CM – CF) = 96.424 (TM – TF) = 4.98 (TM – CM) = -51.16 (TF – CF) = 40.25
8. Engineering is only for smart people	(CM – CF) = 1.000 **(TM – TF) = .0454** (TM – CM) = .8837 (TF – CF) = 1.000	(CM – CF0 = 1.99 (TM – TF) = 29.31 (TM – CM) = 32.53 (TF – CF) = 3.20
9. To study engineering you have to be talented	(CM – CF) = 1.000 **(TM – TF) = .0551** (TM – CM) = .2343 (TF – CF) = 1.000	(CM – CF) = -17 (TM – TF) = .7671 (TM – CM) = 43.60 (TF – CF) = -2.00
10. Boys know more about engineering than girls do	**(CM – CF) = .0451** **(TM – TF) = .0029** (TM – CM) = 1.000 (TF – CF) = .3082	(CM – CF) = 71.95 (TM – TF) = 37.62 (TM – CM) = 5.24 (TF – CF) = 39.61
11. Boys are more capable of doing engineering jobs than girls	(CM – CF) = .1285 **(TM – TF) = .0106** (TM – CM) = 1.000 (TF – CF) = .6676	(CM – CF) = 61.98 (TM – TF) = 33.76 (TM – CM) = 4 (TF – CF) = 32.40

As in the analysis of the PATT individual statements, the analysis using the PATE individual statements while controlling for gender and treatment reports a majority of significant differences related to the change in male and female pair comparisons rather than the change in treatment and control pair comparisons. This finding further validates previous findings in this study and in the review of literature indicating that regardless of participation in the UUR program, males reported more interest in engineering generally than females.

The first statement's report suggests the common trend found in previous analyses that the ControlMale pair significantly agrees more than the ControlFemale pair that they will probably get an engineering job later on. However, when considering the disparity between the TreatmentMale and TreatmentFemale pairwise comparison and the ControlMale and ControlFemale pairwise comparison, this statement's finding indicates that females in the treatment reported more interest in engineering careers than females in the control. This finding is further validated within the exclusive treatment female and control female pairwise comparison. Females in the treatment reported to more likely consider an engineering career later on than females in the control. This report shows that the TreatmentFemale pair agrees 60.87 points more than the ControlFemale that they will probably get a job in engineering later on. Among the many findings of this research this is a key finding showing a strong impact of the UUR program on females' interest in engineering careers.

The second and third statements in Table 4-17 indicate common findings in this research, which is that, the ControlMale pair is more likely to agree that they would enjoy a job in engineering than the ControlFemale pair. This again, indicates that males in general are more interested in engineering than females. Interestingly, when visually comparing the results from the treatment male and female comparison, the gender difference does not have as much of an effect. The average score difference between the male and female treatment pairs (TM – TF) is 25 points. This finding is consistent with the previous statement's finding and further indicates that females in the UUR program reported similar scores as males regarding interest in engineering careers and more interest in engineering careers than females who did not participate in the program.

The report for the statement, *If there was a school club about engineering, I would certainly join it* indicates two significant results. The first is the common trend between differences in gender; that is, the ControlMale pair is more likely to agree with the statement than the ControlFemale, indicating again, that males who did not participate in the UUR program are more interested in engineering than females.

The second finding is a difference in treatment and control, rather than gender. Consistent with the first statement, *I will probably get a job in engineering later on,* the result shows that the TreatmentFemale pair agrees with this statement 60 points more than the ControlFemale pair.

This finding indicates a strong effect of the treatment, meaning females in the UUR reported more interest in continuing participation in engineering activities than females who did not participate in the program. Triangulation with the focus group interview analysis supports this finding as is discussed in section 4.3.4.

The next three statements, related to the consequences of engineering, had similar findings for the TreatmentMale/ControlMale (TM – CM) pairwise comparisons. Each statement analysis indicated that the ControlMale pair scored significantly higher than the TreatmentMale. This means that the ControlMale pair agrees more than the TreatmentMale with the following statements: 1) Engineering makes everything work better , 2) Engineering is important in life, and 3) Everybody needs engineering. Similar results were found in the PATT analysis using individual statements, yet triangulation with the focus group interview analysis helped provide insight into the statistically negative relationship. Whereas, triangulation efforts to explain the negative relationship related to engineering was not present in the focus group analysis. For this reason, researchers extend recommendations to further investigate this finding.

Lastly, significant findings from the individual statements related to engineering being for boys and girls indicate the historical trend that boys are generally more interested, capable and have a more accurate perception of engineering than girls. This is evident in the analysis of the statement, *Boys are more capable of doing engineering jobs than girls* where the TreatmentMale pair agree 33 points more than the TreatmentFemale pair (p-value = .0106). Interestingly, when the [(TM) – (TF)] pairwise comparison is compared with the [(CM) – (CF)] pairwise comparison, the females in the control indicated more similar responses to the males in the control resulting in a less significant p-value at alpha .05. This finding indicates that females in the UUR program reported a more positive self-perception of their own capability to engineering jobs than females in the control. Thus continuing to validate previous findings related to females' in the UUR program reporting more interest in engineering careers and activities than females who did not participate.

Similar conclusions can be drawn from the analysis of the statement, *Boys know more about engineering than girls do.* Results indicate a significant difference in both the male/female control pairwise comparison and the male/female treatment pairwise comparison. Results indicate that males reported they know more than girls do about engineering. However, when considering the treatment male and female pairwise comparison, females again reported a more positive self-perception of their own knowledge about engineering than females in the control. This finding is important because it further validates females in the UUR program reporting more interest and perception of engineering than females in the control. Continued validation for this key finding through triangulation of findings from the focus group analysis is discussed in the next section.

4.3.4 Constant Comparative Analysis Triangulating Findings from the PATT and PATE Assessment Scores Controlling for Gender and Treatment

In review, the previous three sections reported statistical findings from three distinct methods while controlling for gender and treatment: 1) The entire composite PATT and PATE assessment scores. 2) The composite PATT and PATE categorical scores. 3) The individual PATT and PATE assessment statements. The following discussion will briefly review findings from only the individual PATT and PATE assessment statements, then support findings by triangulating the constant comparative analysis findings. The purpose of doing this is because within the PATT and PATE individual statements, findings from each composite PATT and

PATE categorization analyses are covered, eliminating unnecessary repetition of findings from the constant comparative qualitative analysis.

Both the PATT and PATE individual statements report a majority of significant differences related to the change in male and female pairwise comparisons rather than the change in treatment and control pairwise comparisons. 23 statements combined from both assessments were found to be statistically significant or practically significant, however, 14 unique statements are reported in this section.

The following paragraphs discuss triangulation of findings from the qualitative analysis with coinciding PATT and PATE significant findings. This analysis begins with statements at the top of Tables 4-16 and 4-17 and commences from one statement to another below it, unless a statement from one assessment is not reported on the other assessment, in which case the analysis indicates which assessment the finding belongs to.

The first triangulated statements come from both PATT and PATE assessments and relate to career aspirations in both assessments; 1) I will probably get a job in engineering later on, 2) I would enjoy a job in technology/engineering, and 3) I would like a career in technology/engineering. Key statistical findings indicated that females in the UUR program were more interested in considering working in engineering than females not in the program *and* females in the UUR program reported little difference in their scores related to engineering when compared to males' scores.

Findings from the constant comparative analysis support these findings through two major classifications, *Influence of the design process* and *Participants improved awareness and perception of technology and engineering*. The emergent properties associated with these classifications are 1) changed interest in technology and engineering (positive and negative) and 2) understanding of technology, engineering and related careers. Support for the classifications emerged from each of the 9 interviews and informed the following sub-categories, a) desire to learn more, b) what was learned about technology and engineering-related content or careers, c) seeing-learning-doing, and d) success or failure through trial and error. Evidence includes the following statements from females (see Table 4-7 for more results):

- "I think it would be really cool to be an engineer and to work with technology because it's cool to work with things that can help people… a lot of times people think it (engineering) is boring, but it's actually really cool once you're doing it. Before the program, I was kind of interested in engineering, but after, I just thought it was really cool and I was really interested." *(9-girl 9:45)*

- "Now I want to know how things work and what all the engineers do so much for us. I want to learn to do stuff like that with machines." *(4-girl 9:07)*

- "Personally I liked to be challenged but having a job where you can manufacture circuit boards or motor would be really complex but if it worked it would be ALL worth it! That would be an interest to me." *(8-girl 4:09)*

- "[Before the program], I wouldn't have considered engineering as a job because I always thought of engineering as a job where you don't get paid very much and kind of boring. All you do is build bridges and stuff. So I always thought more about the other fun jobs, BUT after researching it and doing all this (building an ROV in UUR) you learn that it's fun." *(5-girl 4:18)*

Additionally, evidence of girls' responses being similar to boys' regarding engineering emerged from each of the 9 interviews and informed the same classifications as above. Supporting responses from boys and girls are as follows:

- "It (the UUR program) was cool because I didn't know how to make something move. I liked being an engineer. It's something I have never done before." *(1-girl 1:48)*

- “I thought it (the UUR program) was cool because I’ve never really done a lot with engineering before. I’ve built treehouses with my dad, but I haven’t built anything that would go underwater and be motorized.” *(9-boy 10:35)*

- “I’m more interested (in engineering) because it was a lot fun seeing how the wires and the circuit board and stuff work. Seeing how all that works and that we got to have hands-on activities.” *(10-boy 1:53)*

- “I was more interested because I got to see how you actually build a ROV and the process it takes. Building the ROV is what made the program more interesting.” *(1-girl 5:45)*

Statistical findings from the statement, *If there were a school club about technology/engineering, I would certainly join it* indicated that females’ in the UUR program were more interested in joining a technology or engineering club than those who were not in the program.. The constant comparative analysis again supports this finding through the two previous major classifications, *Influence of the design process* and *Participants improved awareness and perception of technology and engineering*. Evidence includes female student statements related to the following sub-categories: a) hadn’t done something like UUR before, b) desire to learn more 3) what was learned about technology and engineering and related content or careers, 4) seeing – learning – doing, and 5) confidence boost. Examples emerged from each of the 9 interviews and include the following:

- “I would want to join because even doing just science things it’s just fun, and you get to experiment, and it’s not about following the exact rules- you can try different things out.” (*5-girl 6:19*)

- “I would join (another one) because you get to make things or rebuild things you never thought you could actually do.” (*5-girl 6:55*)

- “It’d be cool to figure out all the cool tools that we use because I didn’t even know there was a soldering iron or wire stripper etc.” (*4-girl 9:20*)

- “I would probably want to join another group (club) because I think it’s really cool how things work and how they’re put together. It’s interesting.” *(9-girl 5:08)*

The next statement comes from the PATT assessment only. The statistical analysis of the statement *There should be more education about technology* indicated that the ControlMale agreed significantly more than the ControlFemale. However, within the TreatmentMale and TreatmentFemale comparison there was no significant difference, meaning that both treatment male and females’ scores were similar. This finding isn’t surprising considering the curriculum and hands-on technological activities involved in the UUR program, but it is important because it indicates that females in the UUR program were made more aware of the importance of learning about technology than females not in the program. Triangulation using the constant comparative analysis further validates the treatment’s male and female scores through the major classification, *Participants improved awareness and perception of technology and engineering*. Examples emerged from 7 of the 9 interview episodes and include the following:

- “There should be more [technology education] because if people get involved only in the jobs that ‘aren’t very hard’ then once this generation has passed away then we’ll have no one to build our roads and make inventions that are essential. [*Interviewer*] ‘Did the ROV experience help you understand that?’ “A little bit, the researching that we did helped me understand that as well.” *(5-girl 7:44*)

- “I think that engineering is really fun and that this is just a small part, and if you decided to take lots of classes and maybe major in it then you could do really cool things; and figure out things about the world that no one else knows.” *(4-boy 8:23)*

- “Ya, I think there should be [more education about technology] so that people better understand technology and aren’t just assuming ‘Hey a car just moves because it’s supposed too.’ The ROV experience helped me think that.” (*3-boy 9:18*)

- “I think there should be [more education] because then we could have more engineers and improve technology to make life easier for everybody.” *(3-girl 9:36)*

Statistical findings from the statements, *Technology/Engineering makes everything work better, Technology/Engineering is important in life,* and *Everybody needs engineering* indicated that the TreatmentMale pair were made more aware of the positive and negative consequences of technology and engineering than the ControlMale pair. The constant comparative analysis shows some support for the technology portion of this finding, however, there is little qualitative evidence supporting the statements regarding engineering. The major classification remains the same as the previous finding; *Participants improved awareness and perception of technology and engineering*. Evidence supporting the statement *Technology makes everything work better* comes from males' interview responses and informs the sub-category, a) what was learned about technology and engineering related content and careers. Examples emerged from 6 of the 9 interviews and include the following:

- "I think we definitely need engineering, but we don't need ALL of the technology. For example, phones can be good and bad." *(4-boy 7:15)*

- "Before I thought that technology was boring, it was about making devices (manufacturing them). Technology is more complicated than I thought." *(1-boy 7:58)*

- "I think there are some things about it that we really need it in our society to just make the world a better place. Vehicles, technologies, and to discover new things. But then again, as our teacher taught us (in the UUR program), it would be kind of dangerous because if people had robots work for them etc. then people could get away with bad things." *(10-Boy 12:02)*

- "At the very beginning of the whole ROV experience, like clear back in September she (the teacher) had a PowerPoint that explained the reason we are doing this is because of the technological race across different states. So our state is trying to be most educated and get the best people so we can thrive in it. Which I think is good and bad since we are competing against each other." *(7-boy 14:38)*

This qualitative finding is important because it provides deeper insight into the impact of the UUR program. In this case, males in the UUR program reported that they were made more aware of both the positive and negative consequences of technology. See Table 4-9 for more examples.

Additionally, the statements *Everyone needs technology* and *Everybody needs engineering* demonstrate a significant difference amongst the control male and female comparisons but not for the treatment male and female comparisons. This specific finding suggests that the TreatmentMale and TreatmentFemale pairs were made more aware of the need for technology and engineering than the ControlMale and ControlFemale pairs. Supportive qualitative findings stem from female and male responses within the major classifications, *Influence of the design process* and *Participants improved awareness and perception of technology and engineering.* Evidence emerged from 8 of the 9 interviews and includes the following statements:

- "I definitely don't think there should be less (technology and engineering education) because especially now in our world, tech is such a big part of our lives now (if you think about it, little kids know how to work phones better than their parents). It's just becoming more and more a part of our lives and what we do every day. Just like this, you're using your phone (to record) and you've got a laptop back there and phone books etc. All these technologies that are coming to us. So I think we need to be able to learn how to not only make and work with stuff, but also to understand because we're just gonna be seeing it every day!" *(7-boy 13:27)*

- "I just want to say that I've never really planned on doing an engineering job, but now that I see this and have done the [UUR program] I know that it's a very important job in our society, and if we need more people for anything ya know, it would be this." *(10-girl 11:09)*

- "Without ROV's how would we be able to make discoveries under the water, or if there was a volcano or something, we as human beings can't always go to places that maybe a robot can and we can learn and discover new things that way. Make things easier." (10-boy 13:24)

In conclusion, triangulation reported in this section represents the qualitative support for the following key statistical findings: 1) Males were more interested in technology *and* engineering than females, regardless of whether they participated in the UUR ROV program. 2) Male and female students in the UUR program were more interested and had a more positive perception of engineering than those who did not participate in the UUR ROV program. 3) Females in the UUR program reported more interest in engineering careers and activities than females not in the program, 4) Participating males reported more awareness of the positive and negative consequences of technology than those who did not participate.

4.4 Impact of the UUR Program: Controlling for Gender and Treatment

4.4.1 Individual STEM Interest Questions

The analysis using the individual STEM interest questions yielded 9 statistically significant findings while controlling for gender and treatment. Refer to Table 4-18 for a display of these results.

Table 4-18: Individual STEM Interest Questions

STEM Interest Question	P-value(s)	Score Difference
1. How much do you like Science?	**(CM – CF) = .0048** **(TM – TF) = .0308** (TM – CM) = 1.000 (TF – CF) = .0139	(CM – CF) = 89.55 (TM – TF) = 29.96 (TM – CM) = 1.83 (TF – CF) = 61.46
2. How much do you like Math?	(CM – CF) = .8988 (TM – TF) =1.000 (TM – CM) = 1.000 (TF – CF) = 1.000	(CM – CF) = 39.17 (TM – TF) = .8170 (TM – CM) = -10.09 (TF – CF) = 28.25
3. Rate how good you are Math	(CM – CF) = 1.000 (TM – TF) =1.000 (TM – CM) = 1.000 (TF – CF) = 1.000	(CM – CF) = 17.40 (TM – TF) = -14.55 (TM – CM) = -15.36 (TF – CF) = 16.59

Table 4-18 Cont'd.

4. Rate how good you are at science	**(CM – CF) = .0110** (TM – TF) = .4124 (TM – CM) = 1.000 (TF – CF) = .0056	(CM – CF) = 83.88 (TM – TF) = 19.64 (TM – CM) = 3.00 (TF – CF) = 67.28
5. I would like to be an engineer some day	**(CM – CF) = .0075** **(TM – TF) = .0040** (TM – CM) = 1.000 (TF – CF) = .3198	(CM – CF) = 89.77 (TM – TF) = 37.98 (TM – CM) = -11.15 (TF – CF) = 40.68
6. I would like to take an engineering class	**(CM – CF) = .0305** **(TM – TF) = < .0001** (TM – CM) = 1.000 (TF – CF) = 1.000	(CM – CF) = 77.68 (TM – TF) = 55.34 (TM – CM) = -11.56 (TF – CF) = 10.77

The first significant finding comes from the first question in Table 4-18, which states, *How much do you like Science?* The report indicates that within the control, the score difference between the male and female responses is very large. This comparison suggests that the male control likes science much more than the female control.

However, within the same statement, among the treatment male and female responses, the result is less significant than the control male and female result. The analysis continues to be statistically significant at alpha .05 but it is less statistically significant than the male and female responses within the control. In fact, the report suggests that the female response was only 29 points less than the male. The disparity between the treatment male and female pairwise comparisons and control male and female pairwise comparisons indicate that females in the UUR program reported more interest in science than females not in the program.

Furthermore, the third finding, also within the first statement in Table 4-18, indicates that females reported that they liked science more than the female control pairs. This finding relates to the previous key finding because it indicates that the females in the UUR program were more interested in science and liked science more than the control group.

The next two findings relate to the student's self-perception in their ability to do Science; specifically, regarding the statement *Rate how good you are at science.* This result indicates, and may be related to the previous question regarding the level of interest in science, such that the males' interest in science may be high because they perceive themselves as also being good at science when compared to the female control group. Looking at the pairwise comparison between the female treatment and control, the report indicates that the treatment female group rates themselves as being significantly good at science. This finding helps support the previous finding between the female treatment and control pairwise comparison, such that females in the UUR program reported that they had a more positive perception and self-efficacy of science.

4.4.2 Individual STEM Perception Questions

The analysis using the individual STEM perception questions yielded two statistically significant findings while controlling for gender and treatment. Refer to Table 4-19 for a display of these results. Refer to Appendix 3 for full results regarding the individual STEM perception questions.

Table 4-19: Individual STEM Perception Questions

STEM Perception Question	P-value(s)	Score Difference
1. I am good at science	**(CM – CF) = .0439** (TM – TF) = .9352 (TM – CM) = 1.000 (TF – CF) = .0561	(CM – CF) = 72.19 (TM – TF) = 15.31 (TM – CM) = -4.03 (TF – CF) = 52.83

The first finding indicates similar findings in previous questions. That is, males in the control group perceive themselves as being good at science significantly more than girls in the control perceive themselves as being good at science. The second finding, although not statistically significant at alpha .05, yet suggests that females in the UUR program perceive themselves to be good at science (i.e., they scored on average 52 points more than girls in the control group (p-value = .0561)). This finding supports previous findings, which indicate that females in the UUR program reported a more positive interest, perception and self-efficacy in science.

4.4.3 Composite STEM Perception Questions

This section of the analysis using the composite score of the STEM perception questions is included in this report because it coincides with the method of analysis used for the PATT and PATE composite score analyses. Since the same scale was used to measure each question in the STEM perception section, a composite score for all STEM perception questions was attainable. Refer to Table 4-20 for a display of these results.

Table 4-20: Composite Score for All STEM Perception Questions

Composite STEM Perception	P-value(s)	Score Difference
All the individual scores added up from the treatment/control and gender groups	(CM – CF) = 1.000 (TM – TF) = .5641 (TM – CM) = 1.000 (TF – CF) = 1.000	(CM – CF) = 36.57 (TM – TF) = 18.92 (TM – CM) = -18.33 (TF – CF) = -.06

There were no significant findings as a result of combining all scores between each control/treatment and gender pairs. This result indicates that there were no differences between the responses of all gender/treatment pairs; essentially meaning the UUR program shows no significant impact on perception of STEM when using these statements and this method of categorizing statements.

4.5 Summary of Findings in Chapter 4

According to the different categorizing methods of the PATT and PATE assessments, as well as the STEM interest and perception questions, this study revealed several findings regarding the impact a ROV curriculum competition program has on student interest in, and perception of, sTEm - specifically technology and engineering. Of the many findings, key findings include: 1) Males were more interested in technology *and* engineering than females regardless of whether they participated in the UUR ROV program. 2) Male and female students in the UUR program were more interested and had a more positive perception of engineering than those who did not participate in the UUR ROV program. 3) Females in the UUR program reported more interest in engineering careers and activities than females not in the program. 4) Females in the UUR program reported more interest and self-efficacy in science than females not in the program. 5) Males in the UUR program reported more awareness of the positive and negative consequences of technology and engineering than those who did not participate. The details of these findings and a discussion about their implications are discussed in Chapter 5.

5 SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

5.1 Statement of Problem

There is limited research on the impact ROV activities or programs have on student interest and perception of technology and engineering. Specifically, there is inadequate research using a reliable assessment instrument to investigate interest and perception of technology and engineering after participating in an ROV program. This research study used quantitative (a "3-in-1" assessment instrument) and qualitative (observations and focus group interviews) methods to investigate the impact the Utah Underwater Robotics (UUR) program had on student interest and perception of technology and engineering. A control and treatment methodology was used in this study.

5.2 Background

There is limited literature that discusses the significance a Remotely Operated Vehicle (ROV) program has on student interest in, and perception of technology and engineering in an educational setting. A careful review of literature relating to the use of ROVs reveals that ROVs have been used in education as early as 1992 for the purpose of applying science and engineering knowledge, tools and techniques to the understanding and use of the marine environment (MATE, 2015), and to increase the number of skilled technicians to work in "strategic advanced-technology fields." (Nichols & Williams, 2009)

Educational programs that have used ROVs suggest ROV-based curriculum and activities can be a tool to enhance interest and improve perception regarding technology and engineering (Hurd et al., 2013; Melchior et al., 2005). There is, however, limited literature using empirical data indicating the actual impact an ROV activity or program has on student interest in and perception of technology *and* engineering. Programs such as SeaPerch (AUVSI Foundation, 2013; Heilman, 2015), Utah Underwater Robotics (Hurd et al., 2013; Wright et al., 2014), Waterbotics (Eguchi, 2014; B. McGrath et al., 2008) and MATE (Clough & Lundsford, 2006; J. Zande & Sullivan, 2003) all use underwater robotics as part of STEM curriculum. Most of the literature involving these ROV programs consists of magazine articles or overall reports of the curriculum and experiential design for the particular program, demonstrating anecdotal evidence of increased student engagement and interest in STEM-related areas, robotics efficacy and STEM learning in general (Heilman, 2015; B. McGrath et al., 2008; Stolkin et al., 2007).

5.3 Methodology

Data was collected in three ways: 1) Observations made at the Utah Underwater Robotics (UUR) 3rd annual ROV competition held March 18, 2015 (see appendix 7), 2) student control (N = 47) and treatment (N = 280) responses to a “3-in-1” assessment, and 3) focus group interviews with 54 elementary students who participated in the UUR ROV competition.

5.3.1 Observations

Notes and observations of over 400 students preparing and competing using their personally built ROV, were collected during the March 18th 2015 UUR competition, held in Lehi Utah. The local recreation center included a 25-yard, 8-lane pool where students conducted their

ROV team challenges. A semi-random selection of teachers, principals and students (based on their availability during the competition and willingness to be interviewed) were asked questions throughout the day. Questions posed to principals and teachers included: What impact do you think this ROV program has on the students? Did you see a difference in student classroom behavior or engagement after the beginning of the program? What do you think the program teaches students? What would you say is the best thing about the program? Students were asked questions such as: What was one thing you learned from this experience? What was the best part of your experience? Would you do this again if you had the chance? Teams were also asked questions about how prepared they felt for the competition. Questions were informed by the study's research purpose: investigating how an ROV program impacts student interest in, and perception of technology and engineering.

5.3.2 The 3-in-1 Assessment

In previous years the UUR program administered a survey-questionnaire, which consisted of two categories of statements and questions focused on STEM interest and STEM perception. Alone, the original survey-questionnaire was determined inadequate for the purpose of this study. Consequently, the researchers wanted to include a reliable assessment instrument, and the PATT-USA assessment-modified from the European 1985 PATT-was chosen as this reliable instrument. The PATT-USA was chosen because of its proven reliability as an instrument from the field of technology education.

At the time of this study, the PATT-USA assessment did not include statements regarding engineering. Thus, the researchers created their own modified version of the PATT-USA, called the Pupils' Attitude Towards Engineering (PATE). This survey-assessment includes identical statements and categories of the PATT except wherever the word *technology* is used, *engineering* is put in its place.

Thus, the final survey assessment used for this study consists of three assessments, the PATT-USA, PATE and original UUR STEM questions combined into one instrument (see Table 3-4). This assessment is further referred to as the "3-in-1." The 3-in-1 assessment was administered to a control and treatment group.

5.3.3 Participant Selection Method

Participation in the UUR program is voluntary. Interested teachers, after school coordinators, or parents simply signup for the UUR using the online portal. It is a free program, which provides ROV supplies, training, and curriculum support.

Teachers who decide to use it in school, embed the curriculum and design process activities into their regular class time schedule. Students in these situations do not self-select into the UUR program. Approximately 75% of the participants are from schools where UUR has been embedded into the regular school day and curriculum. Teachers or parents who participate in UUR as an after school club activity or at home, are invited to also use the same curriculum, however, in this case, the students generally have self-selected into the program. The UUR participant responses to the 3-in-1 survey assessment reported 62% male.

5.3.4 Control Group Selection

In this study it was not possible to administer the 3-in-1 survey-assessment before the 2014-2015 ROV competition. Because of this it was decided that a control group of students who did not participate in the UUR program be identified and take the 3-in-1 survey. The control group was chosen based on the following criteria: 1) Students from the same school as those who participated in the ROV program and 2) students of the same age and grade of those who participated in the ROV program. The control group responses to the 3-in-1 survey assessment reported 48% male.

At the time of the study, all control group participants were 11-12 years old and attended the same school as participants in the focus group interview (also 11-12 years old). Students in the control had a similar learning environment as participants in the interview focus group, and had taken similar technology classes as participants in the UUR program of ages 11-12.

5.3.5 Focus Group

The focus group methods of this study involved two classes whose teachers used the UUR program as part of their science curriculum during school. Thus, qualitative findings of this study represent a sample population of students who mostly experienced UUR as part of their school day. Consequently, the focus group method also used a sample population of students who only participated in UUR because it was part of their regular school day.

Focus group interviews were conducted one week after the ROV competition. Nine groups, each group comprising 5-6 elementary students, were interviewed at their school in a study room just two doors down the hall from each student's homeroom classroom. Each interview episode lasted between 15 to 20 minutes.

5.3.6 Data Analysis

The analysis of the data consisted of two parts: 1) Quantitative statistical analysis of the survey results, and 2) Qualitative analysis of the focus group interviews and observations from the annual UUR competition. The quantitative analysis compromised aggregating data in excel, then analyzing the data using JMP Pro 12. The qualitative analysis utilized a constant comparative method informed by an emergent theme analysis.

Aggregation of the UUR survey-assessment results were analyzed according to the six categories in the PATT and PATE assessments. These categories include: 1) [Technology/Engineering] career aspirations. 2) Interest in [technology/engineering]. 3) Consequences of [technology/engineering]. 4) [Technology/Engineering] is difficult. 5) [Technology/Engineering] is for boys and girls. 6) Tediousness towards [technology/engineering].

Data was also analyzed according to the two categories created in the original UUR survey, which focused on STEM interest and STEM perception. This was done for the purpose of identifying where differences of interest and perception in technology and engineering occurred within the study.

Statistical analyses were performed on the 3-in-1 survey responses, specifically the Wilcoxon/Kruskal Wallis test and Dunn's Method for Joint Ranking test. The Kruskal Wallis test is used for non-parametric distributions; since the distribution is not known to be normal, the researchers decided to use this test to determine general statistical significance between the means of the control and treatment groups. After analyzing for statistical significance at alpha .05, between the treatment and control groups, any comparison with statistical or practical significance was further investigated by controlling for both gender *and* treatment using Dunn's Method for Joint Ranking. Dunn's Method for Joint Ranking is a non-parametric test used for multiple comparisons. The following four pairs were used in the analysis: TreatmentMale (TM), TreatmentFemale (TF), ControlMale (CM), and ControlFemale (CF). In each comparison, one pair's mean was subtracted from another. Each of the following four pairwise comparisons were analyzed: 1) (CM – CF), 2) (TM – TF), 3) (TF – CF), 4) (TM – CM).

The second part of the analysis utilized a constant comparative method as outlined by Glaser and Strauss (1967), Strauss and Corbin (1990), and Charmaz, (2002) with an emergent theme analysis. The constant comparative goal is to explain how some aspect of the social world 'works' (Glaser & Strauss, 2009) and aligns with the goal of the current research. This method outlines specific procedures that deliver results similar to the desired results for the current study, that is, to ensure that the resulting theories emerge from the data and not from preconceived notions or an *a priori* framework (Glaser & Strauss, 2009).

Steps of this process are as follows:

1. Uncover "action verbs" (Charmaz, 2014) as a means to find codes for emerging themes in the data.
2. Utilize memoing during the coding (and over the entire course of analysis) process to note interesting discrepancies, concepts or anomalies.
3. Classify differing and similar concepts in order to form categories and further understand the concepts involved in the data.
4. Group and categorize classifications into properties and dimensions (Strauss & Corbin, 1990).

5. Search for patterns where groups of properties align themselves with various dimensions (Strauss & Corbin, 1990).

Once the qualitative analysis of the interviews and observational notes was complete, the final triangulation process of comparing the statistical analysis results to the qualitative analysis results began.

5.4 Findings and Conclusions

This section includes a reporting and an analysis of the collected data, and outlines the significant findings. The significant findings are: 1) Males were more interested in technology *and* engineering than females, regardless of whether they participated in the UUR ROV program. 2) Male and female students in the UUR program were more interested and had a more positive perception of engineering than those who did not participate in the UUR ROV program. 3) Females in the UUR program reported more interest in engineering careers and activities than females not in the program. 4) Females in the UUR program reported more interest and self-efficacy in science than females not in the program. 5) Males in the UUR program reported more awareness of the positive and negative consequences of technology and engineering than those who did not participate.

5.4.1 Males Were More Interested in Technology *and* Engineering than Females, Regardless of Whether They Participated in the UUR ROV Program.

96 pairwise comparisons controlling for the gender variable were analyzed using the PATT and PATE assessments; meaning the [(TM) – (TF)] (TreatmentMale – TreatmentFemale), and the [(CM) – (CF)] (ControlMale – ControlFemale) pairs. Of these comparisons, 30 (16 from the PATT-7 of which were CM-CF, and 14 from the PATE-6 of which were CM-CF) were

found to have statistical or practical significance. Of the 30 significant results, 100% of them recorded significant higher mean values for the male pairs (TreatmentMale or ControlMale). This means that males reported more interest in technology and engineering than females regardless of participation in the UUR ROV program.

The STEM interest and perception portion of the 3-in-1 assessment analyzed 30 pairwise comparisons controlling for gender. Of these comparisons, nine were found to have statistical or practical significance. As with the PATT and PATE assessments, 100% of the nine comparisons recorded higher mean values for the male pairs than the female. This suggests the same finding as the PATT and PATE analyses.

Triangulation with the focus group analysis supports this finding when considering which gender more frequently expressed less interest towards the UUR program during the focus group interviews. The qualitative analysis indicates that more females expressed less interest towards activities and team dynamics embedded in the UUR curriculum and competition than males. In fact, there were no males who expressed less interest in the UUR program. Evidence of females' lower interest emerged from 4 of the 9 interview episodes. See Table 4-8 for examples.

5.4.2 Male and Female Students in the UUR Program Were More Interested and had a More Positive Perception of Engineering than Those who did not Participate in the UUR ROV Program

The *Engineering career aspirations* category includes four statements and the *Interest in engineering* category contains six. Of the four in *Engineering career aspirations*, three statements: 1) I will probably get a job in engineering later on (p-value = .0410), 2) I would enjoy a job in engineering (p-value = .0238), and 3) I would like a career in engineering (p-value = .0811) all resulted in statistically significant larger mean scores for the male pair than the female pair (ControlMale – ControlFemale). Meaning, males from the control group reported more interest in engineering careers than control females.

A similar finding resulted from the *Interest in engineering* category, which consists of three significant statements: 1) Engineering lessons are important (p-value = .1601), 2) If there were a school club about engineering, I would certainly join it (p-value = .0305), and 3) I enjoy repairing things at home (p-value = .0007). This data suggests that control group males were more interested in engineering than control females. However, males and females in the treatment pairwise comparisons did not report a large statistically significant difference in mean scores for any of the above statements. This finding is important because it suggests males *AND* females in the UUR program were more interested and reported a more positive perception of engineering than those not in the UUR ROV program.

Triangulation with the focus group interview constant comparative analysis validates findings that treatment males and females reported more interest and perception of engineering than control males and females and provides more insight to the impact of the UUR program.. Thematic evidence emerged from each of the 9 focus group interviews and informed major classifications including I*nfluence of the design* process and P*articipants improved awareness and perception of technology and engineering.* Examples include the following (see Tables 4-7 and 4-9 for more examples):

- "I would want to do it (the ROV program) again because of all the fun things that come from it, you learn more and you see how stuff works." *(9-boy 5:26)*

- "I just want to say that I've never really planned on doing an engineering job, but now that I did it (UUR) I know that it's a very important job in our society. If we need more people for anything, ya know (it should be for engineering)." *(10-girl 11:09)*

- “I thought it was going to be really cool at first, so when we started doing it I was getting so excited because it would be so cool. But then it was even more fun because when we actually used it (the ROV) in the water it was like getting a birthday present that you’ve kept in storage for like 3 years! Wahoo! Let’s do this- this is so cool!” *(9-boy 19:47)*

- “When we were doing the ROV program I definitely have a lot more appreciation for engineers because we just built this tiny robot that could just do some simple tasks; so for what engineers do which is more complex, it would take a lot more time. This (the ROV) took months for us so I definitely have a lot more appreciation for them.” *(9-girl 12:50)*

- “My interest in engineering changed because, as soon as we got in the pool I looked from a different angle and realized the different ways that we should have planned in the beginning of what we were going to do. If we had done that before we would have had a better strategy.” *(2-boy 1:28)*

- “What made me more interested about how things work is when my group was soldering the wires I started thinking ‘Well, this wire goes here,’ so it started making me think about what happens- like what makes it go and everything. I hadn’t really thought about what makes things work before this experience. I just thought they did and that’s how it was.” *(3-girl 5:10)*

5.4.3 Females in the UUR Program Reported More Interest in Engineering Careers and Activities than Females not in the Program

Among other statements, the analysis of two specific PATE assessment statements exclusively indicate that females in the UUR program reported more interest in engineering careers and activities than females not in the program: 1) I will probably get a job in engineering later on (p-value = .0186) and 2) If there were a school club about engineering, I would certainly join it (p-value = .0211). The TreatmentFemale pair scored a statistically significant average of 60 points more than the ControlFemale pair in each of these statements.

Triangulation with findings from the qualitative constant comparative analysis validates this finding and provides more insight to the impact of the UUR program. Supporting evidence informed the major classifications, I*nfluence of the design process* and P*articipants improved awareness and perception of technology and engineering* and emerged from each of the 9 focus group interviews. Examples include:

- "I probably would [take an engineering class] because I just like creating things and seeing after your work is done what you did. This experience helped me realize that more, because at first I didn't think I liked engineering, but after I did it I realized it was really fun!" *(2-girl 9:13)*

- "After everything was done, I thought about possibility of becoming an engineer. I liked it." *(3-girl 3:15)*

- "I would say that now I really want to do more with engineering and to be in different programs that would help me to have more experience in building robotics and stuff like that." *(Interviewer): 'Have you ever been interested in this stuff before?'* "I've watched my dad do stuff since he's a construction worker etc. but I haven't ever really done anything like this." *(8-girl 5:24)*

- "It was cool because I didn't know how to make something move… I liked being an engineer. It's something I have never done before." *(1-girl 1:48)*

5.4.4 Females in the UUR Program Reported More Interest and Self-Efficacy in Science than Females not in the Program

Data show that females in the UUR program scored significantly higher on average, on the following question and statements; 1) How much do you like science? (p-value = .0139), 2) Rate how good you are at science (p-value = .0056), and 3) I am good at science (p-value = .0561). It is important to note possible factors at play with this finding. For instance, many of the teachers who volunteered to participate in the UUR program were science teachers.

Accordingly, the curriculum included more science concepts than math, such as observation, prediction, experimentation, discovery, keeping records, research, propulsion and buoyancy, thus providing many opportunities to have positive science-related experiences.

Many, if not each of the teams observed at the competition included females, who appeared engaged and involved in making many of the decisions during the competition. Interestingly, it's worth noting that the winners for the overall UUR competition over the past two years have been female.

5.4.5 Males in the UUR Program Reported More Awareness of the Positive and Negative Consequences of Technology and Engineering than Those who did not Participate

The PATT and PATE categories labeled *Consequences of technology/engineering* include the following statements: 1) Engineering makes everything work better, 2) Engineering is important in life, 3) Engineering lessons are important, and 4) Everybody needs engineering. Of these four statements, three had a statistical negative relationship between males in the treatment and control. The ControlMale pair average score for the statement *Technology/Engineering makes everything work better* was 65 (technology) and 66 (engineering) points higher than the TreatmentMale average score (p-value = .0110 and .0104). The ControlMale pair score for the statement *Technology/Engineering is important in life* was 71 (technology) and 77 (engineering) points higher than the TreatmentMale score (p-value = .0039 and .0012). The ControlMale pair score for the statement *Everybody needs engineering* was 51 points higher than the TreatmentMale pair (p-value = .0906). Further investigation reveals that these statistical negative relationships indicate males in the UUR program were made more aware of the positive and negative consequences of technology. However, there was limited revelation for the negative statistical relationship regarding statements including engineering.

Triangulation with focus group interviews qualitative constant comparative analysis suggests that most students in the UUR program understand the importance of technology, but were made more aware of technology-related positive and negative consequences through the UUR program. Evidence emerged from each of the 9 focus group interviews and lead to the major classification labeled, *Participants improved awareness and perception of technology and engineering.* Examples include student responses when reflecting on how the UUR program influences their thoughts and feelings towards technology:

- "I think there are some things about it that we really need it in our society to just make the world a better place, like better vehicles, technologies, and to discover new things. But then again, as our teacher said it would be kind of dangerous because if people had robots work for them etc. then people could get away with bad things." *(10-Boy 12:02)*

- "The teacher talked to us about that there is a big call (need) for people in the technology stuff (workforce) and yet there is a need for people in construction, there is a shortage there as well as the coal mining industry and power etc. More people are going towards technology. So I think it (technology) can be good and bad." *(7-boy 15:33)*

- "Technology is good, but as long as it still allows us to do things ourselves- otherwise we'll all end up like the movie 'Wall-E' with all the fat people in the chairs." *(2-Boy 13:10)*

- "At the very beginning of the whole ROV experience, like clear back in September, she (the teacher) had a PowerPoint that explained the reason why we're doing this is because of the technological race across different states – so our state is trying to be the most educated and get the best people so we can thrive in it. Which I think is good and bad since we're competing against each other." *(7-boy 14:38)*

5.5 Study Delimitations

Despite the beneficial findings of this research, limitations to this study include:

- Pre and post PATE and PATT assessments were not given to the same students to measure increase or decrease of interest and perception of technology and engineering. UUR students only completed the POST PATE and PATT assessments.
- Too many statements in the survey assessment, causing potential survey fatigue.
- The control group consisted of only two 6^{th} grade classes with students from the same school.
- Curriculum and learning objectives taught throughout the duration of the UUR program were not detailed and clear, neither was it monitored closely for variation in student understanding and experience.
- Only one ROV program was part of this study

5.6 Conclusions and Recommendations

The findings of this study suggest that a competition-based curriculum involving ROV technology, such as the UUR program can make a positive impact on student interest and perception of technology, engineering, and science. Specifically, this study shows that males and females in the UUR program were more interested and had a more positive perception of engineering than those who did not participate in the UUR ROV program.

Leaders of similar educational and outreach STEM curricula should consider ROV activities and programs as an influential learning experience for secondary education students.

However, a more robust curriculum implementation with more precise curriculum learning objectives should be developed. Such an effort may have a more significant impact on student interest and ability in STEM related subject matter.

Finally, it is recommended that additional research be conducted to further solidify and explore the impact ROV programs have on student interest in and perception of STEM content, specifically technology and engineering. The scope of this research was limited to the UUR program; further research should investigate other ROV programs. Additionally, educational stakeholders should evaluate their current STEM curriculum and activities, investigate the impact they are having, and at minimum incorporate more hands-on engineering activities similar to the ROV program described in this study that highlight technological and scientific principles.

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APPENDICES

APPENDIX 1 – PATT, PATE AND STEM PERCEPTION COMPOSITE SCORES

PATT Assessment Control Factor	P-Value	Mean Difference	Z	Standard Error Difference
PATT Treatment and Gender	(CM – CF) = .0027	99.2723	3.51	28.26
	(TM – TF) = .0070	36.8087	3.24	11.33
	(TM – CM) = .5967	-35.78	-1.64	21.72
	(TF – CF) = 1.000	26.66	1.24	21.34
PATT Treatment	Prob>Z = .9696	-	-0.03	-

PATE Assessment Control Factor	P-Value	Mean Difference	Z	Standard Error Difference
PATE Treatment and Gender	CM – CF = .0023	100.506	3.55	28.26
	TM – TF = .0222	32.896	2.90	11.33
	TM – CM = .8187	-32.34	-1.48	21.72
	TF – CF = .5917	35.25	1.65	21.34
PATE Treatment	Prob>|Z| = .6777	-	-0.41	-

STEM Perception	P-Value	Mean Difference	Z	Standard Error Difference
STEM Treatment and Gender	(CM – CF) = 1.000	36.57	1.29	28.17
	(TM – TF) = .5641	18.92	1.67	11.29
	(TM – CM) = 1.000	-18.33	-0.85	21.65
	(TF – CF) = 1.000	-0.64	-0.03	21.27
STEM Treatment	Prob>|Z| = .6777	-	-0.41	-

APPENDIX 2 – PATT AND PATE CATEGORICAL SCORE ANALYSIS

PATT Category Controlling For Treatment and Gender	P > |Z|	Z	Mean Difference
Technological career aspirations	CM-CF = .2591	2.022	56.95
	TM-TF = .0764	2.491	28.13
	TF-CF = 1.000	0.893	19.00
	TM-CM = 1.000	-0.452	-9.79
Interest in technology	CM-CF = .0258	2.854	80.58
	TM-TF = .1558	2.226	25.20
	TF-CF = 1.000	0.665	14.18
	TM-CM = .3455	-1.899	-41.18
Consequences of technology	CM-CF = .1010	2.390	67.34
	TM-TF = 1.00	0.661	7.52
	TF-CF = 1.000	-0.163	-3.47
	TM-CM = .0206	-2.925	-63.33
Technology is difficult	CM-CF = 1.00	-0.582	-16.39
	TM-TF = .0522	2.623	29.60
	TF-CF = 1.00	-0.276	-5.88
	TM-CM = .3816	1.854	40.11
Technology is for boys and girls	CM-CF = .0055	3.316	90.95
	TM-TF = .0066	3.262	35.88
	TF-CF = .0623	2.562	53.08
	TM-CM = 1.00	-0.039	-1.97
Tediousness towards technology	CM-CF = .9300	1.422	39.78
	TM-TF = .6026	1.642	18.42
	TF-CF = 1.000	-0.013	-.29
	TM-CM = 1.000	-1.008	-21.69

PATE Category Controlling For Treatment and Gender	P > |Z|	Z	Mean Difference
Technological Career Aspirations	CM-CF = .0417	2.699	56.95
	TM-TF = .6755	1.586	28.13
	TF-CF = .2758	1.995	19.00
	TM-CM = 1.000	-0.722	-9.79
Interest in Technology	CM-CF = .0461	2.665	80.58
	TM-TF = .4112	1.821	25.20
	TF-CF = 1.000	1.352	14.18
	TM-CM = 1.000	-1.188	-41.18
Consequences of Technology	CM-CF = .0681	2.538	67.34
	TM-TF = 1.000	0.245	7.52
	TF-CF = 1.000	0.071	-3.47
	TM-CM = .0118	-3.095	-63.33

Technology is Difficult	CM-CF = 1.000 TM-TF = .0499 TF-CF = 1.000 TM-CM = .6730	-0.498 2.639 1.588 -0.445	-16.39 29.60 40.11 -5.88
Technology is For Boys and Girls	CM-CF = .0143 TM-TF = .0035 TF-CF = .2526 TM-CM =1.000	3.037 3.435 2.032 -0.162	90.95 35.88 53.08 -1.97
Tediousness Towards Technology	CM-CF = .6770 TM-TF = .6958 TF-CF = 1.000 TM-CM =1.000	1.585 1.571 0.142 -1.102	39.78 18.42 -.29 -21.69

PATT Category Controlling for Treatment	**P > |Z|**	**Z**	**Mean Difference**
Technological Career Aspirations	.5925	-0.535	8.113
Interest in Technology	.5234	.638	-9.691
Consequences of Technology	.0387	2.067	-31.29
Technology is Difficult	.2076	-1.260	19.066
Technology is For Boys and Girls	.0389	-2.065	30.42
Tediousness Towards Technology	.5649	.575	-8.666

PATE Category Controlling for Treatment	**P > |Z|**	**Z**	**Mean Difference**
Technological Career Aspirations	.2748	-1.092	16.541
Interest in Technology	.7497	-0.319	4.852
Consequences of Technology	.0413	2.040	-30.848
Technology is Difficult	.3391	-0.955	14.464
Technology is For Boys and Girls	.1007	-1.641	24.261
Tediousness Towards Technology	.5970	0.528	-7.943

APPENDIX 3 – PATT, PATE AND STEM INTEREST AND PERCEPTION INDIVIDUAL STATEMENT SCORE ANALYSIS

PATT Statement Controlling for Treatment and Gender	p-Value	Z	Mean Difference
I will probably get job in technology later on	CM-CF = .5322 TM-TF = .1763 TM-CM = 1.000 TF-CF = 1.000	1.702 2.178 0.049 1.150	46.21 23.7 1.04 23.58
I would enjoy a job in technology	CM-CF = .0392 TM-TF = .0837 TM-CM = 1.000 TF-CF = .9976	2.720 2.458 -0.895 1.384	74.69 27.07 -18.89 28.708
I would like a career in Technology	CM-CF = 1.000 TM-TF = .0270 TM-CM = 1.000 TF-CF = .9024	1.323 2.840 1.171 1.438	36.03 31.01 24.52 29.57
A job in technology would be interesting	CM-CF = .9423 TM-TF = .3976 TM-CM = .7438 TF-CF = 1.000	1.415 1.836 -1.538 -2.445	38.72 20.15 -32.34 -13.74
I would rather not have technology lessons at school	CM-CF = 1.000 TM-TF = .4236 TM-CM = 1.000 TF-CF = 1.000	1.193 1.808 -0.455 0.156	32.86 19.96 -9.62 3.25
If there was a school club about technology I would certainly join it	CM-CF = .0336 TM-TF = .0036 TM-CM = 1.000 TF-CF = .2131	2.770 3.425 0.252 2.102	76.11 37.84 5.32 43.62
I am not interested in technology	CM-CF = .3070 TM-TF = 1.000 TM-CM = 1.000 TF-CF = 1.000	1.950 0.861 -1.089 1.015	52.75 9.52 -23.08 21.14
There should be more education about technology	CM-CF = .0937 TM-TF = .4704 TM-CM = .3269 TF-CF = 1.000	2.417 1.760 -1.923 0.309	65.56 19.13 -40.07 6.33
I enjoy repairing things at home	CM-CF = .0007 TM-TF = 1.00 TM-CM = .0057 TF-CF = 1.000	3.861 1.359 -3.304 1.027	106.50 15.03 -70.04 21.41
Technology makes everything work better	CM-CF = .5657 TM-TF = 1.000 TM-CM = .0110 TF-CF = 1.000	1.673 0.292 -3.115 -1.108	45.86 3.21 -65.62 -22.93
Technology is important in life	CM-CF = .3496 TM-TF = 1.000 TM-CM = .0039 TF-CF = 1.000	1.893 0.519 -3.411 -1.237	51.70 5.68 -71.56 -25.51

Technology lessons are important	CM-CF = .6226 TM-TF = 1.000 TM-CM = .7157 TF-CF = 1.000	1.626 1.132 -1.557 -0.030	44.31 12.37 -32.60 -0.62
Everybody needs technology	CM-CF = .0531 TM-TF = 1.000 TM-CM = .4369 TF-CF = .5950	2.617 -0.015 -1.794 1.648	71.84 -0.16 -37.83 34.17
You have to be smart to study technology	CM-CF = 1.000 TM-TF = .0892 TM-CM = 1.000 TF-CF = 1.000	-0.874 2.435 1.089 -1.342	-23.95 26.77 22.95 -27.77
Technology is only for smart people	CM-CF = 1.000 TM-TF = .0622 TM-CM = .5137 TF-CF = 1.000	-0.157 2.563 1.719 0.177	-4.30 28.14 36.16 3.65
To study technology you have to be talented	CM-CF = 1.000 TM-TF = .0900 TM-CM = .2353 TF-CF = 1.000	-0.322 2.432 2.062 0.377	-8.84 26.76 43.47 7.81
You can study technology only when you are good at both mathematics and science	CM-CF = 1.000 TM-TF = .8783 TM-CM = 1.000 TF-CF = 1.000	-0.722 1.452 1.213 -0.492	-19.82 15.99 25.60 -10.20
Boys are able to do practical things better than girls	CM-CF = .0016 TM-TF = .0268 TM-CM = 1.000 TF-CF = .0662	3.653 2.842 -0.772 2.542	98.45 30.72 -15.98 51.73
Boys know more about technology than girls	CM-CF = .0114 TM-TF = .0067 TM-CM = 1.000 TF-CF = .0945	3.104 3.258 0.031 2.414	83.88 35.29 0.64 49.27
Boys are more capable of doing technological jobs than girls	CM-CF = .0970 TM-TF = .0111 TM-CM = 1.000 TF-CF = .1428	2.405 3.112 0.713 2.260	64.58 33.51 14.72 45.84
I do not understand why anyone would want a job in technology	CM-CF = .5269 TM-TF = .6894 TM-CM = 1.000 TF-CF = 1.000	1.707 1.576 -1.368 0.029	46.78 17.32 -28.82 0.62
Most jobs in technology are boring	CM-CF = 1.000 TM-TF = .9456 TM-CM = 1.000 TF-CF = 1.000	0.675 1.413 -0.668 -0.534	18.51 15.52 -14.08 -11.05
I think machines are boring	CM-CF = .3829 TM-TF = .2594 TM-CM = .6412 TF-CF = 1.000	1.853 2.021 -1.612 -0.258	50.41 22.04 -33.70 -5.29
A technological hobby is boring	CM-CF = .8520 TM-TF = 1.000 TM-CM = 1.000 TF-CF = 1.000	1.468 1.284 -0.948 0.296	40.19 14.09 -19.95 6.12

PATE Statement Controlling for Treatment and Gender	P > |Z|	Z	Mean Difference
I will probably get job in engineering later on	CM-CF = .0410 TM-TF = .3751 TM-CM = 1.000 TF-CF = .0186	2.704 1.862 0.357 2.957	73.70 20.35 7.47 60.87
I would enjoy a job in engineering	CM-CF = .0238 TM-TF = 1.000 TM-CM = 1.000 TF-CF = .2517	2.880 1.032 -1.210 2.034	78.93 11.34 -25.48 42.09
I would like a career in engineering	CM-CF = .0811 TM-TF = .1074 TM-CM = 1.000 TF-CF = .2684	2.469 2.367 -0.005 2.007	67.46 25.93 -0.10 41.40
A job in engineering would be interesting	CM-CF = .1605 TM-TF = 1.000 TM-CM = .3677 TF-CF = 1.000	2.215 0.876 -1.871 0.563	60.77 9.63 -39.45 11.66
I would rather not have engineering lessons at school	CM-CF = 1.000 TM-TF = .2473 TM-CM = 1.000 TF-CF = 1.000	1.026 2.041 0.146 0.426	28.21 22.50 3.10 8.85
If there was a school club about engineering I would certainly join it	CM-CF = .0305 TM-TF = .2003 TM-CM = 1.000 TF-CF = .0211	2.801 2.127 0.330 2.918	77.12 23.48 6.98 60.66
I am not interested in engineering	CM-CF = 1.000 TM-TF = 1.000 TM-CM = 1.000 TF-CF = 1.000	0.580 0.702 0.089 0.487	15.95 7.74 1.88 10.13
There should be more education about engineering	CM-CF = .2900 TM-TF = .7671 TM-CM = 1.000 TF-CF = 1.000	1.974 1.5226 -1.361 0.420	53.85 16.65 -28.52 8.65
Engineering makes everything work better	CM-CF = .5181 TM-TF = 1.000 TM-CM = .0104 TF-CF = 1.000	1.175 0.682 -3.133 -1.278	47.01 7.50 -66.00 -26.46
Engineering is important in life	CM-CF = .6917 TM-TF = 1.000 TM-CM = .0012 TF-CF = 1.000	1.574 -1.190 -3.717 -1.063	42.87 -12.99 -77.77 -2185
Engineering lessons are important	CM-CF = .5030 TM-TF = 1.000 TM-CM = .6129 TF-CF = 1.000	1.728 0.684 -1.634 0.262	47.19 7.49 -34.28 5.39
Everybody needs engineering	CM-CF = .0026 TM-TF = 1.000 TM-CM = .0906 TF-CF = .3102	3.519 0.454 -2.429 1.945	96.42 4.98 -51.16 40.25

You have to be smart to study engineering	CM-CF = 1.000 TM-TF = .6373 TM-CM = 1.000 TF-CF = 1.000	-0.266 1.615 0.368 -0.835	-7.56 17.77 7.77 -17.32
Engineering is only for smart people	CM-CF = 1.000 TM-TF = .0454 TM-CM = .8837 TF-CF = 1.000	0.072 2.670 1.449 0.155	1.99 29.31 32.53 3.20
To study engineering you have to be talented	CM-CF = 1.000 TM-TF = .0551 TM-CM = .2343 TF-CF = 1.000	-0.619 2.605 2.063 -0.104	-17.03 28.73 43.60 -2.15
You can study engineering only when you are good at both mathematics and science	CM-CF = 1.000 TM-TF = .2089 TM-CM = 1.000 TF-CF = 1.000	-0.964 2.110 1.382 -0.990	-26.46 23.23 29.16 -20.53
Boys know more about engineering than girls	CM-CF = .0451 TM-TF = .0029 TM-CM = 1.000 TF-CF = .3082	2.672 3.485 0.253 1.948	71.95 37.62 5.24 39.61
Boys are more capable of doing engineering jobs than girls	CM-CF = .1285 TM-TF = .0106 TM-CM = 1.000 TF-CF = .6676	2.300 3.125 0.200 1.592	61.98 33.76 4.14 32.40
I do not understand why anyone would want a job in engineering	CM-CF = .2789 TM-TF = 1.000 TM-CM = 1.000 TF-CF = 1.000	1.991 1.379 -1.265 0.615	54.28 15.07 -26.51 12.67
Most jobs in engineering are boring	CM-CF = 1.000 TM-TF = 1.000 TM-CM = 1.000 TF-CF = 1.000	1.159 1.090 -1.025 -0.084	31.69 11.94 -21.53 -1.74
A engineering hobby is boring	CM-CF = 1.000 TM-TF = .5100 TM-CM = 1.000 TF-CF = 1.000	0.832 1.722 -0.401 -0.219	22.74 18.87 -8.43 -4.53

PATT Statement Controlling for Treatment	P > |Z|	Z	Mean Difference
I will probably get job in technology later on	.2961	-1.044	15.253
I would enjoy a job in technology	.5546	-0.590	8.731
I would like a career in Technology	.0382	-2.072	30.336
A job in technology would be interesting	.1613	1.400	-20.605
I would rather not have technology lessons at school	.9539	0.057	-0.854
If there was a school club about technology I would certainly join it	.0480	-1.977	29.191
I am not interested in technology	.9469	-0.066	0.986
There should be more education about technology	.3415	0.951	-13.859
I enjoy repairing things at home	.1626	1.396	-20.697
Technology makes everything work better	.0035	2.919	-42.998
Technology is important in life	.0014	3.198	-46.930
Technology lessons are important	.3169	1.001	-14.648
Everybody needs technology	.9893	0.013	-0.197
You have to be smart to study technology	.9533	0.057	-0.841
Technology is only for smart people	.1341	-1.498	22.038
To study technology you have to be talented	.0616	-1.869	27.561
You can study technology only when you are good at both mathematics and science	.5648	-0.575	8.494
Boys are able to do practical things better than girls	.1200	-1.554	22.511
Boys know more about technology than girls do this	.0411	-2.042	29.651
Boys are more capable of doing technological jobs than girls	.0171	-2.384	34.398
I do not understand why anyone would want a job in technology	.4283	0.792	-11.66
Most jobs in technology are boring	.4574	0.743	-10.940
I think machines are boring	.2550	1.138	-16.633
A technological hobby is boring	.7401	0.331	-4.878

PATE Statement Controlling for Treatment	P > |Z|	Z	Mean Difference
I will probably get job in engineering later on	.0105	-1.044	37.461
I would enjoy a job in engineering	.4558	-0.590	10.993
I would like a career in engineering	.0991	-2.072	24.221
A job in engineering would be interesting	.4257	1.400	-8.553
I would rather not have engineering lessons at school	.5695	0.057	8.416
If there was a school club about engineering I would certainly join it	.0114	-1.977	37.436
I am not interested in engineering	.6360	-0.066	7.01
There should be more education about engineering	.6141	0.951	-7.43
I enjoy repairing things at home	.1623	1.396	-20.707
Engineering makes everything work better	.0025	2.919	-44.5894
Engineering is important in life	.0006	3.198	-49.8755
Engineering lessons are important	.3840	1.001	-13.22
Everybody needs engineering	.8463	0.013	-2.244
You have to be smart to study engineering	.8111	0.057	-3.573
Engineering is only for smart people	.1916	-1.498	20.335
To study engineering you have to be talented	.1264	-1.869	22.591
You can study engineering only when you are good at both mathematics and science	.7081	-0.575	6.433
I do not understand why anyone would want a job in engineering	.7595	0.792	-5.503
Most jobs in engineering are boring	.4962	0.743	10.992
A engineering hobby is boring	.7594	0.331	-5.490

STEM Interest Question/Statement		P > |Z|	Z	Mean Difference
How much do you like…? (1=Not at all, 2=I don't love it, 3=It's ok, 4=I like it, 5=I love…)	Science	.0120	-2.523	36.068
	Math	.4924	-0.685	10.033
Rate how good you are at… (1=I'm terrible, 2=A little below average, 3=I'm average, 4=A little above average, 5=I am really good)	Math	.9935	0.008	0.132
	Science	.0076	-2.669	38.62
I would like to be an engineering some day (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree)		.1868	-1.320	19.75
I would like to take an engineering class (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree)		.7017	-0.383	5.72

STEM Perception/Self Efficacy Statement (1=Strongly Disagree, 2=Disagree, 3=Somewhat Disagree, 4=Somewhat Agree, 5=Agree, 6=Strongly Agree)	P > |Z|	Z	Mean Difference
An engineer is someone who uses science to build new and useful things	.0407	-2.046	28.561
The world has enough engineers	.0052	2.792	-40.473
Engineers don't make much money	.1498	1.440	-21.052
It is hard to find a job if you become an engineer	.0849	1.723	-25.312
I am good at math	.8760	-0.156	2.288
I am good at science	.0597	-1.883	27.245
I am good at thinking up new inventions	.3874	-0.864	12.86
I am very creative	.8430	-0.198	2.841
The most important thing about getting a job is how much money you make	.0515	1.947	-28.691

APPENDIX 4 – TEACHER INFORMED CONSENT FORM

Teacher Informed Consent Form

An Educational Survey Concerning Engineering and Technology

Dear Teachers:

As part of my graduate research I (Daniel Bates), along with Dr. Geoff Wright, will be conducting an educational research study this fall and spring with junior high schools in several Wasatch Front school districts. Part of this study includes asking teachers to voluntarily participate in a survey where they rate their ability to teach engineering concepts. We would appreciate it if you would be willing to participate in this study.

The purpose of this study is to investigate the impact hands-on, school-based robotics programs have on teacher's perceived ability to teach on engineering topics. Programs such as UUR are of great interest to government agencies because of a growing concern that fewer students are pursuing education and careers in STEM-related fields. This study is beneficial in that it will help to assess whether teachers who participate such programs feel like they are becoming better engineering educators

There are minimal risks associated with this study. The survey consists of 52 questions and should take less than 30 minutes. Participation in this study is strictly voluntary and you are free to withdraw at any time without consequences. All surveys will be anonymous so that it will not be possible to connect a specific set of answers with the student who gave them. Collected material will be stored in a locked office to which only Dr. Geoff Wright has access.

If you approve of taking this survey, please sign the agreement form at the bottom of this page. If you have any questions about your child's rights as a research participant feel free to contact the BYU IRB Administrator (A-285 ASB, Provo, UT 84604; 801-422-1461). If you have any questions about this specific study feel free to contact Dr. Geoff Wright or myself.

Dr. Wright (Professor of Technology and Engineering Education at Brigham Young University):
email: geoffwright@byu.edu phone number: 801-422-7804 office: 230 SNLB, BYU

Daniel Bates (Graduate Student of Technology and Engineering Ed. at Brigham Young University):
email: dbates12@gmail.com phone number: 435-890-8142

Thank you for your cooperation,

Daniel Bates

Participant Consent:

I (print) ________________________________, am willing to take the survey described above.

Signature ____ Date _____________________

APPENDIX 5 – FOCUS GROUP: STUDENT INFORMED CONSENT FORM

Student Agreement Form
An Educational Focus Group Interview Concerning The ROV Experience

Dear Students:

My name is Daniel Bates and I am a student at BYU. I am interested in what pre high school students think and feel about engineering and technology. In order to answer this question I will be hosting a focus group, made of 4-6 students, asking questions and having a conversation about your experience. It would be very helpful for me if you were willing to participate in this focus group. I would like to have as many students as possible participate so I can see and get a feel for all of the different opinions that students like you have. If you are willing to be a part of this I would greatly appreciate it.

However, I want you to know that you should not feel pressured to participate in the focus group. If your parents would not like you to take it, or if you really don't want to, you do not need to. The survey will not have any effect on your grades, your performance at school, or your teacher's attitude toward you.

As I said before, the focus group will be about your experience in the program. I only want to know what you understand and feel about your experience. This focus group will ask your name and what grade you are in, but the responses will be coded so that there will be no way to connect the answers you gave with you. The focus group will ask you to have a conversation about specific moments that happened during the experience and how you feel about them. The interview will probably not take longer than 25 minutes and may take place during class or after school.

If you are willing to participate in this focus group interview please sign this form below and return it to your teacher. Without this signed formed you will not be able to participate in the interview. If you have any questions about the survey please talk to your teacher or parents who are welcome to contact me.

Thank you for your help,

Daniel Bates

Student Permission:

I (print) ________________________________, am willing to participate in the focus group interview described above.

Signature of Student____ Date ___________

APPENDIX 6 – PARENTAL CONSENT FORM

Informed Consent Form

An Educational Survey Concerning Engineering and Technology

Dear Parents:

As part of my graduate research I (Daniel Bates), along with Dr. Geoff Wright, will be conducting an educational research study this fall and spring with junior high schools in several Wasatch Front school districts. Part of this study includes asking students to voluntarily participate in a survey and/or in a focus group interview consisting of 4-6 students about their understanding and interests in science, technology, engineering and mathematics (STEM). The Utah Underwater Robotics (UUR) program in which your child participates has been selected for this study.

The purpose of this study is to investigate the impact hands-on, school-based robotics programs have on student's attitudes towards STEM subjects. Programs such as UUR are of great interest to government agencies because of a growing concern that fewer students are pursuing education and careers in STEM-related fields. This study is beneficial in that it will help to assess whether such programs are indeed helpful in exciting students about STEM subjects or whether new programs need to be developed.

There are minimal risks associated with this study. The survey consists of 30 questions worded for a middle school student reading level. The survey should take less than 35 minutes for the students to complete and consists of questions such as "I would like to take a class to learn more about engineering." The survey will be given on a computer using Qualtrics software during the regular UUR club time. If you would like to see a copy of the survey before your student decides to participate, you can find a link to the survey questions at rov.byu.edu under the communication tab, under the date September 30th. If you contact me I would also be happy to send you a copy.

Also, because focus groups include discussion of personal opinions, extra measures will be taken to protect each participant's privacy. The researcher will begin the focus group by asking the participants to agree to the importance of keeping information discussed in the focus group confidential. [He or she] will then ask each participant to verbally agree to keep everything discussed in the room confidential and will remind them at the end of the group not to discuss the material outside. Only the researcher will have access to the data collected. Any tapes and transcripts of the focus group will be destroyed after one year or at the end of the study.

The purpose of this letter is to inform parents of the study and obtain approval for your child or dependent to participate in the study. Participation in this study is strictly voluntary and students are free to withdraw at any time without consequences. All surveys will be anonymous so that it will not be possible to connect a specific set of answers with the student who gave them. Collected material will be stored in a locked office to which only Dr. Geoff Wright has access.

If you approve of your child or dependent participating in this study, please sign the agreement form at the bottom of this page and have them return it to their teacher before Thursday, March 26th.

If you have any questions about your child's rights as a research participant feel free to contact the BYU IRB Administrator (A-285 ASB, Provo, UT 84604; 801-422-1461). If you have any questions about this specific study feel free to contact Dr. Geoff Wright or myself.

Dr. Wright (Professor of Technology and Engineering Education at Brigham Young University):
email: geoffwright@byu.edu phone number: 801-422-7804 office: 230 SNLB, BYU
Daniel Bates (Graduate Student of Technology and Engineering at Brigham Young University):
email: dbates12@gmail.com phone number: 435-890-8142

Thank you for your cooperation,
Daniel Bates

Parental Permission:

I (print) ______________________________, give permission for my son/daughter,

_________________________________ to participate in the aforementioned survey.

Signature of Parent or Legal Guardian______________________________ Date ___________

Student Permission:

I (print) ______________________________, am willing to take the survey described above.

Signature of Student____ Date __________

APPENDIX 7 – OBSERVATIONS AND FIELD NOTES

<table>
<tr><th colspan="4">Purpose for observations</th></tr>
<tr><td colspan="4">What impact does the ROV experience have on student interest and perception of technology and engineering?</td></tr>
<tr><th colspan="4">Observations at the competition</th></tr>
<tr><td colspan="2">There are a lot of students engaged. Some students look nervous</td><td colspan="2">Many parents and grandparents came to show support and cheer on their students</td></tr>
<tr><td colspan="2">Students arguing over what needs to be done in order to complete the challenge.</td><td colspan="2">After a particularly long struggle to get their ROV to sink, team members started to shout, “YAY! YAY! We got it working! Its working!”</td></tr>
<tr><td colspan="2">There is a tense feeling in the atmosphere as students begin to compete</td><td colspan="2">The whole arena counts down “5-4-3-2-1!” as the horn sounds to signal teams’ ROVs to enter the water.</td></tr>
<tr><td colspan="2">Some teams brought walkie talkies so they could communicate from different viewpoints in the arena</td><td colspan="2">Some teams used much bigger motors than others. Also, some ROVs had innovative contraptions to help complete challenges.</td></tr>
<tr><td colspan="2">At the competition, in the gallery area (an auxiliary gym) judges walk around and ask questions to team members standing by their poster display. Some students look very confident, others are obviously nervous.</td><td colspan="2">Some students are very emotional about their performance. After not doing very well, they walk off sad and disappointed while other team members attempt to make them feel better. Still other team members are so excited to be there that they don’t care too much when they didn’t do very well.</td></tr>
<tr><td colspan="2">The awards ceremony is held in the same auxiliary gyms as the poster displays. All students crowd around as different awards are announced. Lots of cheering and shouting.</td><td colspan="2">Males in the group tend to show more analytical problem solving. Ex: “No this wire is this color so it should be going into this spot.” Females appear to be more creative. Ex: “We could have the wire in the wrong spot, let’s try to switch the two. Maybe turn the remote around.”</td></tr>
<tr><th colspan="4">Questions and answers</th></tr>
<tr><td>(to administrators) What impact do you think this ROV program has on the students?

What would you say is the best thing about the program?</td><td>“That the students learn to design by themselves and learn to solve problems as they go along.”

“It’s great that they get to apply what they learn.”</td><td>(to student participants waiting to compete) Are you more nervous or confident?

What was one thing you learned from this experience?

What was the best part of your experience?</td><td>“Nervous. We are worried that it won’t work because one of our wires is loose.”

“I learned how to fuse things together, solder, use a circuit board and other stuff.”

“That we got to build this robot.”</td></tr>
<tr><td>(to teachers) Did you see any behavioral differences before, during or after students began the program?

What does the program teach students?</td><td>“Some ‘trouble’ students became a little more engaged than they usually are with regular school projects.”

“That they can fail and still succeed.”</td><td>(to students after they competed) What are your thoughts about your experience?

Would you do this again if you had the chance?</td><td>“The program was more difficult than we thought it would be. Its hard to accept failure.”

“Yes. Our robot didn’t work. I am going to take it home and figure out why.”</td></tr>
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