THE USE OF SUSTAINED EXPERIENCES IN 4-H FLUID POWER EDUCATION TO INFLUENCE STEM PERCEPTION IN MIDDLE SCHOOL YOUTH

by

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Dedication

To my dad, Gary Bonnett

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To my mom, thank you for consistently pushing me to be better and work harder.
To Dr. José Garcia Bravo, thank you for taking me on as a student and being patient, guiding me, and letting me take my own path in it all. I probably wouldn’t have finished if it wasn’t for you!
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ABSTRACT

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Science, Technology, Engineering and Math (STEM) are at the forefront of conversations in education, not only in Indiana, but across the country. This conversation is crossing boundaries from primary and secondary education, to academia, to government agencies, to industry. The inherent focus on STEM comes from an understanding of the impending job shortage in STEM jobs in the next decades. In the discipline of fluid power, the gap between education and industry with jobs is not easy to see because while the gap is known by industry experts there is a lack of literature documenting the gap. Most education is focused on the university level and preparation, and little effort is focused on gaining the interest of students in a K-12 education.

Through a partnership between Indiana 4-H, Purdue Polytechnic and the National Fluid Power Association, the creation of the 4-H NFPA Fluid Power Challenge was created to bridge the gap not only in STEM education through 4-H STEM programming, but to also give youth an opportunity to learn more about STEM and fluid power careers through this eight-week opportunity. The program focuses on collecting data on career interest, STEM attitudes, and fluid power interest. The focus of this dissertation is on the relationships between students participating in the 4-H NFPA fluid power challenge, years of participation, gender with career, STEM attitudes, and fluid power interest.

Gender and participation were two areas in which significant relationships were found in the data set. The relationship between the two as long as the relationship between before and after participation and career interest creates a picture that both answers the research questions posed in this dissertation, but also links to other research in this area on the matters of gender and STEM interest and careers. This study also highlights the importance of a focus on fluid power, and the impact that is seen specifically in sustained experiences in females who participate in Fluid Power programs.

CHAPTER 1. INTRODUCTION

1.1 Introduction

Science, Technology, Engineering and Math (STEM) skills are at the forefront of education agendas across the nation. Creating interest and preparing youth in STEM careers is a high priority for many, including the Indiana 4-H program (Kuenzi, 2008). STEM job opportunities in hydraulics and pneumatics are growing, while the workforce is aging. With STEM being urged in education from the local and national level, in both the formal and non-formal setting, the amount of STEM degrees issued remains at approximately 17% of all degrees obtained (Kuenzi, 2008). With respect to the number of degrees obtained, the number of jobs in the STEM field by 2022 will reach nine million (“STEM 101: Intro to tomorrows jobs”, 2014). With an influx of focus on the future market of jobs in STEM, a focus on STEM education has emerged in academic research around the different components of STEM.

Research has flourished on project-based learning, experiential learning processes, and STEM learning (Kuenzi, 2008). Researchers such as David Kolb, author of “Experiential Learning: Experience as the Source of Learning and Development”, the Committee on STEM integrated STEM Education, and Nugent, et. al., author of “Impact of Robotics and Geo-Spatial Technology Interventions on Youth STEM learning and Attitudes” have created a foundation of work that has looked at these topics in depth, to lay the groundwork for future research in these areas. The ability for each of these topics to be looked at in different contexts in a variety of research areas and foci in STEM, create a foundational basis for STEM research in K-12 education.

The amount of research specifically on fluid power in K-12 is limited. With the addition of out of school time, and integrated STEM education approaches the topic has very little research pertaining specifically to this area, and even less when you specifically link the audience of 4-H Youth Development. This gap in the research leads to intriguing questions on the possibilities of creating links between specific fluid power education concepts and interest in STEM learning. One obstacle in this way of thinking is that creating sustainable opportunities that capture the interest of youth is a challenge. Creating an experience to learn these skills, engage in integrated STEM learning, as well as creating an interest and link to careers in fluid power, or STEM careers in general, adds another layer of complication, and an area of research that has not been explored to the capacity that is available, from multiple different angles.

Through the 4-H NFPA Fluid Power Action Challenge program, youth receive hands-on opportunities to learn about pneumatics and hydraulics, while also learning integrated STEM skills such as problem solving, teamwork, critical thinking, engineering design process, and other skills. The 4-H NFPA Fluid Power Action Challenge program engages students in grades six through eight with an option for multiple year participation in the program. The program participation averages 75 youth per year. Youth in grades 6th through 8th form teams from diverse areas across the state of Indiana. An average of 18 counties participate each year in the program, with 32 counties participating in the program over the past four years.

Evaluation of student interest in careers in pneumatics, hydraulics, and robotics, as well as integrated STEM skills learned through the 4-H Fluid Power Challenge program is assessed in this research project. This study tracks participants over a three-year period on their interest in careers in fluid power. Conducting this study will help answer questions about the development of programs specific to fluid power education and the link between learning concepts, STEM skill learning and careers to grow educational opportunities for youth in and out of school time, and specifically, an opportunity to grow through the 4-H program in Indiana.

1.2 Statement of Problem

This research study captures perception, knowledge, and skill gain for STEM and fluid power careers. The purpose of this study is to look at existing research in the area of Fluid Power education, as well as STEM education, define the gap that exists in this research, and define the gap in fluid power education at the K-12 level. The study looks at the 4-H Fluid Power Challenge program as a baseline in sustained learning opportunities to address the gap that exists based on research. The study answers the following questions through using a quantitative approach:

RQ1. How does participation in the 4-H Fluid Power Experience increase career interest in STEM careers for participants?

RQ2. How does participation in the 4-H Fluid Power Experience increase attitudes about STEM?

RQ3. How does participation in the 4-H Fluid Power Experience influence positive attitudes about fluid power?

1.3 Scope

4-H Youth development programs, which reside within the Land Grant University System, are recognized most frequently for providing programs in agriculture and food education. The Land Grant University System (LGU) is a group of colleges and universities established by the Morrill Act of 1862, 1890, and 1994 that were established for a focus on agriculture and mechanical arts (Council for agriculture in the land grant university system, 1995). 4-H is housed within this system at universities and colleges.

4-H, and more specifically Indiana 4-H, has a mission of providing hands-on learning opportunities for youth to build life skills through project-based work in the areas of science, citizenship, and healthy living (Indiana 4-H Website, 2016). With science, technology, engineering and math (STEM) experiences, youth learn both experiential and inquiry-based learning opportunities to grow their life skills. This focus, aligned with the Indiana 4-H mission and vision, creates a parameter to establish goals, curriculum, and activities focused around building life skills and STEM opportunities for youth in all 92 counties.

1.4 Purpose

With the rise of career options for this current K-12 generation, it is important to create and sustain educational pathways in which youth can identify, learn, and expand their knowledge and interest in STEM educational opportunities. The lack of fluid power opportunities across the United States in the K-12, and even college realm, create a gap in exposure and interest cultivation for the generation of youth.

The purpose of this thesis is to examine where the K-12 fluid power education currently is, and to look at how the implementation of strategically designed 4-H fluid power programs affect the motivation and interest of youth who participate in those programs. This study is also interested in the difference gender plays within perceptions of youth in these programs. Regional demographics will also be looked at for youth who participate in the 4-H fluid power program, and the impacts that regional demographics play within motivations and interest for the youth that participate.

1.5 Assumptions

The assumptions for this study are as follows:

- Youth participating in the survey answer honestly based on their experiences in this project.
- Participation in the project is voluntary by youth participants and not forced participation by parents.
- Youth create and design their own projects and parental and adult mentors serve only in advisory results.
- Youth attitudes, interests, and ideas are of their own, not of those of their group or other adult volunteers.

1.6 Limitations

The limitations for this study are as follows:

- Youth interest in STEM careers related to their experience in 4-H Fluid Power will be examined.
- Youth knowledge of Fluid Power industry and careers will be examined.
- Youth attitudes of fluid power industry and careers will be examined.
- Youth attitudes and interest in STEM industries will be examined.
- Youth growth in knowledge and attitudes toward fluid power will be examined between the start of the program and the end of the program to establish growth.

1.7 Delimitations

The delimitations for this study are as follows:

- Youth interest in STEM based on other STEM experiences will not be looked at during this study.
- Youth knowledge of each specific STEM area will not be studied specifically in this study.

1.8 Definitions

In the broader context of thesis writing, this dissertation defines the following terms:

Experiential Learning: Youth are involved in an activity, looks back at it critically, determine what was useful or important to remember, and use the information to perform another activity. The process of Do-Reflect-Apply is the cornerstone of this approach (Kolb, et. al, 1999).

<u>Fluid Power</u>: "Fluid power is a term describing hydraulics and pneumatics technologies. Both technologies use a fluid (liquid or gas) to transmit power from one location to another. With hydraulics, the fluid is a liquid (usually oil), whereas pneumatics uses a gas (usually compressed air). Both are forms of power transmission, which is the technology of converting power to a more usable form and distributing it to where it is needed. The common methods of power transmission are electrical, mechanical, and fluid power". (*What is fluid power,* 2016).

<u>Indiana 4-H or 4-H</u>: Provides hands-on learning opportunities for youth to build life skills through project-based work in the areas of science, citizenship, and healthy living (*Indiana 4-H Website*, 2016).

<u>Integration STEM education</u>: "A type of STEM connection, disciplinary emphasis, and duration, size, and complexity of initiative" (Honey, Pearson, & Schweingruber, 2014).

<u>Land Grant University or Land Grant University System (LGU or LGUS)</u>: Public college or universities established by the Morrill Act of 1862, 1890 or 1994 to focus on agriculture and mechanical arts. Each university or college was given land to either establish the college or sell for funding for the university. (Council on agriculture in the land grant university system, 1995).

<u>Project Based Learning (PBL)</u>: "Project-Based Learning (PBL) is an instructional methodology that encourages students to learn and apply knowledge and skills through an engaging experience. PBL presents opportunities for deeper learning in-context and for the development of important skills tied to college and career readiness" (What is project-based learning, 2018).

<u>Out of School Time Programming</u>: "Effective OST programs should be student-centered, employ cooperative learning strategies, and foster skills and attitudes toward STEM through authentic, hands-on activities" (Barker, Larson, & Krehbiel, 2014).

<u>Science, Technology, Engineering, and Math</u>: Experiences created for the targeted audience that expose and grow the learning processes in science, technology, engineering and math (STEM) (Honey et al., 2014).

STEM Literacy: "1. Awareness of the roles of science, technology, engineering, and mathematics in modern society. 2. Familiarity with at least some of the fundamental concepts from each area, and 3. Basic level of application fluency" (Honey et al., 2014).

1.9 Conclusion

In this chapter the research questions were identified for this thesis. An introduction of research information on Fluid Power Education as well as the 4-H NFPA Fluid Power Challenge was introduced. The research study will be guided by understanding of how integrated STEM learning experience shape youth perception, motivation, and experiential learning and inquiry-based learning experiences.

The scope and purpose of this study is to look at the importance of programs like the 4-H NFPA Fluid Power program in creating interest in careers in fluid power, engineering, and other STEM careers. This chapter also provided the necessary definitions for this paper, as well as the assumptions, limitations, and delimitations of this study.

CHAPTER 2. REVIEW OF LITERATURE

2.1 Introduction

Purdue University is the land grant university for the state of Indiana. This designation also makes Purdue University the host to the 4-H program for the state of Indiana. The Indiana 4-H program designates three mission areas as part of their focus in intentional experiential education. Science, Citizenship, and Healthy Living are the three current mission areas for Indiana 4-H.

Through the science education realm, intentional programs and opportunities have been created to address perceived gaps in educational areas within STEM. A new program focused on fluid power education was introduced to help create a pathway for students to learn about careers and opportunities in fluid power, which encompasses both hydraulics and pneumatics. This program was designed to fill a gap between 4-H, fluid power education in K-12, and STEM skills development while creating a sustained learning opportunity for youth.

In this chapter the body of research, that surrounds fluid power, experiential learning, inquiry-based learning, STEM learning in 4-H, and integrated learning approaches will be analyzed. Through this research, an in-depth look into each of these areas will establish research objectives for this study through the gaps and questions that are identified through the literature review.

2.2 What is Fluid Power?

Defining the words fluid power may seem very straight forward if the definition is being looked at from a perspective of straight definition. The difference is that depending on what area or aspect (industry, education, other) that you derive the reference from, the definition can be varied. The definition that is used in this thesis is the definition generated by the National Fluid Power Association, since this research is built on a program created by the National Fluid Power Association:

> Fluid power is a term describing hydraulics and pneumatics technologies. Both technologies use a fluid (liquid or gas) to transmit power from one location to another. With hydraulics, the fluid is a liquid (usually oil), whereas pneumatics

> uses a gas (usually compressed air). Both are forms of power transmission, which is the technology of converting power to more usable form and distributing it to where it is needed. Both are forms of power transmission, which is the technology of converting power to a more usable form and distributing it to where it is needed. The common methods of power transmission are electrical, mechanical, and fluid power (*What is fluid power*, 2016).

This definition helps to set the stage for how fluid power is perceived from an educational lens. For this paper's purpose, the definition of fluid power will be used in instances in which we refer to both hydraulics and pneumatics. The driving factor in this research is the correlating link between youths' interests in STEM careers and the sustained interest in fluid power careers.

According to the NFPA Annual report for 2015 (*What is fluid power*, 2016), fluid power manufacturing is a 19.3 -billion -dollar industry as well as an export of 5.7 billion dollars for the United States. With such a large industry, one issue remains: the disconnect between industry and education. As described in "The Changing Face of Manufacturing in the U.S," Joseph Shea defines the systematic need to create growth and maintain the integrity of manufacturing in the United States, since they compete heavily with foreign manufacturing. His study concentrates on addressing the allure of manufacturing for those interested in STEM careers (Shea, 1984).

As seen in Figure 1 (National Fluid Power Association, 2018) industry identifies that the biggest issue is finding skilled workers that are competent in fluid power skills. They define this as relevant to the work that is necessary for the industry they serve. In 2018, 55% of the manufacturing managers or hiring departments indicated that finding skilled workers competent in what they need to hire, was the number one concern for their company. This was increased from 36% in 2016.

The look at industry and their perspective also needs to be balanced with the education side of fluid power, and how it is being taught. A recent research article that has been published looked at e-learning and manufacturing engineering education (Amm, 2016). Amm examined the use of e-learning for undergraduate students to help connect the needed knowledge with "employment needs" (2016, p. 2). In this article, the author creates an understanding of the balance needed for e-learning, hands-on learning, and lectures.

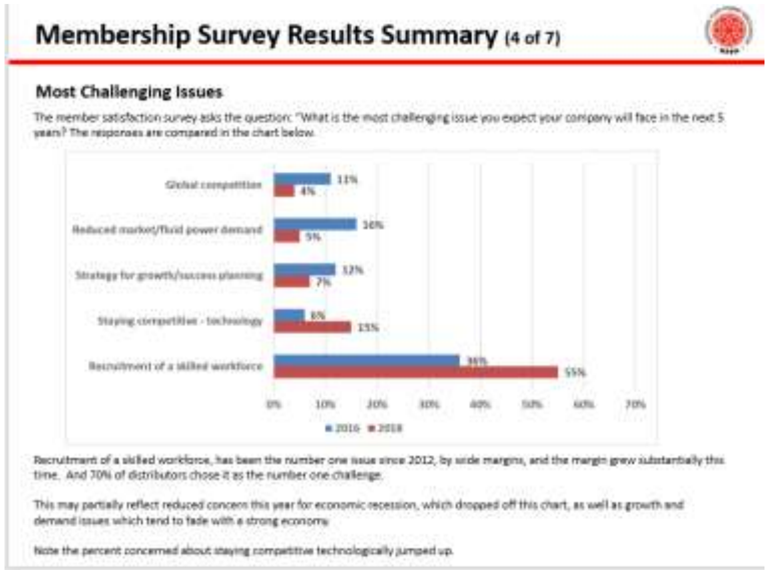


Figure 2-1 Membership survey results for most challenging issues for fluid power companies (NFPA, 2018).

One of the ways to address this issue in fluid power manufacturing is through educational experiences. The issue in this realm, particularly for fluid power, is that courses that are offered in fluid power are few and far between and are mostly offered through technology-based programs. Koski and others agree that increasing the awareness for fluid power starts with classes being offered in programs like mechanical and electrical engineering ("Fluid power education: What went wrong", 1994). This includes offering classes as part of the major, including sections on fluid power in classes, and creating specific certificate programs in fluid power.

The other issue is the lack of research in fluid power education. Most research is focused on the collegiate level and very little research focuses on K-12 STEM. Even though integrated STEM research is abundant (Honey et al., 2014), the amount of research focused on fluid power education is very minimal. The void exists in the area of fluid power K-12 education research as well as program development. The lack of research in this area, opens up an opportunity to answer the question of how can programs and projects designed in this area, fill the gap of learning and exposure in fluid power manufacturing?

This awareness is not only driven in a university classroom, but also is necessary to be driven in the K-12 classroom and communities in which manufacturing jobs are prevalent. Events such as National Manufacturing Day, which has been held in October for the past seven years, is focused on "manufacturers inviting students, educators, community members, politicians into their facilities in an effort to educate on careers and improve public perception" (Manufacturing Day, 2017). A 2015 survey conducted through the National Manufacturing Day created a map of perceptions and needs for the manufacturing industry in changing perceptions and filling gaps in skills and job fulfillment (Deloitte, The Manufacturing Institute, 2016). The survey conducted through Deloitte Consulting and the National Manufacturing Institute looks at skills gap, job gap, and public perception as part of the survey (2016).

One of the key points of the report is focused on the skills gap. According to the "Skills Gap in U.S. Manufacturing, 2015 and Beyond," "3.5 million manufacturing jobs likely need to be filled and the skills gap is expected to result in two million of those jobs going unfilled" (2016, p. 2, para 5). This gap is expected for two reasons: baby boomer retirements (those born in the mid-1940's to mid-1960's) and economic expansion. According to the report this could mean 2 million jobs going unfilled because of reasons like the negative image of manufacturing jobs, lack of STEM skills, and decline of technical education programs in the United States (Deloitte, 2016, p. 2 para 5). According to the study of those surveyed "82% of executives believe the skills gap will impact their ability to meet customer demand" (Deloitte, 2016, p. 2 para 6).

The perception of manufacturing in communities helps define the gap. According to the Deloitte report (2016) most Americans know that manufacturing is necessary in communities, but only 37% of them identified that they would encourage their child to pursue a manufacturing degree (p. 3, para 1). The same survey indicated that "parents who know more about manufacturing are twice as likely to encourage their child to pursue a manufacturing career," (2016, p. 3, para 1). As a result, it is necessary to engage and create connections through community partnerships, partnerships in education, and partnerships with government organization.

Programs like National Manufacturing Day, a program that focuses one day on connecting the manufacturing industry and the public, are one way to address the need to fill the gap and create a more positive perception for manufacturing careers. The need to increase those programs across the United States is one of the goals of the National Fluid Power Association with programs like the Fluid Power Challenge. The gap indicates a need of sustained experiences in manufacturing disciplines like that of fluid power careers.

The other issue is the lack of research in fluid power education. Most research is focused on the collegiate level and very little research focuses on K-12 STEM. Even though integrated STEM research is abundant (Honey et al., 2014), the amount of research focused on fluid power education is very minimal. The void exists in the area of fluid power K-12 education research as well as program development. The lack of research in this area, opens an opportunity to answer the question of how can programs and projects designed in this area, fill the gap of learning and exposure in fluid power manufacturing.

2.3 Integrated STEM and STEM Learning Approaches to Curriculum/Programs

Science, technology, engineering and math (STEM) has been a buzz word in education for the past 10 years (Honey et al., 2014)). According to the National Academy of Sciences, those working in education should have the goals of creating STEM skills in youth through experiences (Honey et al., 2014). Two of these goals that are outlined in the STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research are STEM literacy and 21st century competency skills (Honey et al., 2014). The definition of STEM literacy is defined by this committee as:

1. Awareness of the roles of science, technology, engineering, and mathematics in modern society.
2. Familiarity with at least some of the fundamental concepts from each area, and
3. Basic level of application fluency (Honey et al., 2014).

Like most definitions in science, this is a developing definition as the concepts and ideas around STEM literacy and STEM education continue to advance and change with the evolving educational system and industry needs.

Between STEM literacy and 21st century skills the main concept is to create opportunities and curriculum that provides STEM workforce readiness through the ability of linking K-12 activities to career skills (Honey et al., 2014). The second definition parallels how integrated STEM will be explained for this thesis. STEM integration is defined for this study as a “type of STEM connection, disciplinary emphasis, and duration, size, and complexity of initiative” (Honey et al., 2014). Creating programs and initiatives to address STEM literacy in program means first understanding and defining a definition for STEM literacy and integrated

STEM that is used for the project. The concept must take into consideration the variety in audience, subject matter, and delivery mode that it is addressing.

The reason it is important to define STEM integration is because of the complex way in which STEM integration can be viewed, depending on the need of the viewer. The view can change how it is defined based on the research being conducted or the program or activity that is being designed. This is important within this research because STEM integration will continue to influence how the curriculum is designed to meet the objectives and the goals of the programs, how volunteers and educators are supported, and how the learning environment is defined (Honey et al., 2014).

Another area to look at in STEM education is the challenges that are relevant to STEM education in the 21st century. "Building America's future: STEM education intervention is a win-win" a 2017 article Shoshanna Israel identifies an interrelated challenge of the need for "Policymakers to help educators better prepare our students; to support the economic growth engine that is STEM and empower students to achieve higher financial success" (p. 3). Israel discusses two areas that should be focused on for STEM education which include quality after school programs and curriculum (Israel, 2017). Ball, Huang, Cotton, and Rikard use the wording of "pressurizing the STEM pipeline" instead of "finding the leaks in the pipeline" (Pressurizing the STEM pipeline: An expectancy-value theory analysis of youths' STEM attitudes, 2017). Creating opportunities, quality curriculum and after school programs create a similar thread between the two research articles, with a constant theme of creating quality integrated experiences for youth.

2.4 Project Based Learning and Integrated STEM Education

Project based learning (PBL) is common language in K-12 school curriculum. The idea of project-based learning has spanned multiple subject areas such as education, medicine and engineering (Capraro & Slough, 2013). The definition of project-based learning varies slightly by author, but for this paper, the definition given by Capraro and Slough (2013) in STEM Project Based Learning: An Integrated Science, Technology, Engineering and Mathematics approach will be used. The definition is:

> Project-Based Learning is broader and often is composed of several problems' students will need to solve. It is our belief that PBL provides the contextualized,

> authentic experiences necessary for students to scaffold learning and build meaningfully powerful science, technology, engineering, and mathematics concepts supported by language arts, social studies, and art. (p. 2)

Capraro and Slough (2013) use this definition to create a basis for why using project-based learning and STEM together create an avenue for successful transition from secondary to post-secondary education. Project-based learning integrates not just one subject but creates a synthesis of learning modules that link skill development with content development (Capraro & Slough, 2013). STEM in project-based learning is historically used to define one subject area of the STEM; an example is just science or just technology.

The reason for selecting Capraro and Slough (2013) is that it uses STEM as a basis for an integrated learning approach with project-based learning. This aspect of the definition and research they created around STEM project-based learning has laid a foundation for looking at PBL in STEM to create a holistic look at STEM skill development and transitional opportunity between learning and career. The issue that is created through this research, and most research in PBL, is the focus on in-school, classroom teacher led experiences. This project will focus on creating a baseline for out-of-school time, volunteer led project-based learning experiences.

One area in which PBL is seen in many contexts is through engineering design in school, as well as in out of school settings. The use of the engineering design process model (Figure 2.1) is the basis for curricula such as Project Lead the Way and other state specific standards that are being integrated into schools. In his book, "Make and Test Projects in Engineering Design" Samuel explains the importance of problem-based learning in engineering through creation of projects centered on real world problems in communities and in education. The correlation between PBL and the engineering design process not only exists as part of the learning curriculum, but also as an avenue to connect industry with education (Samuel, 2006). The opportunity to create the link between PBL and engineering design, increases the connection between formal and informal as well.

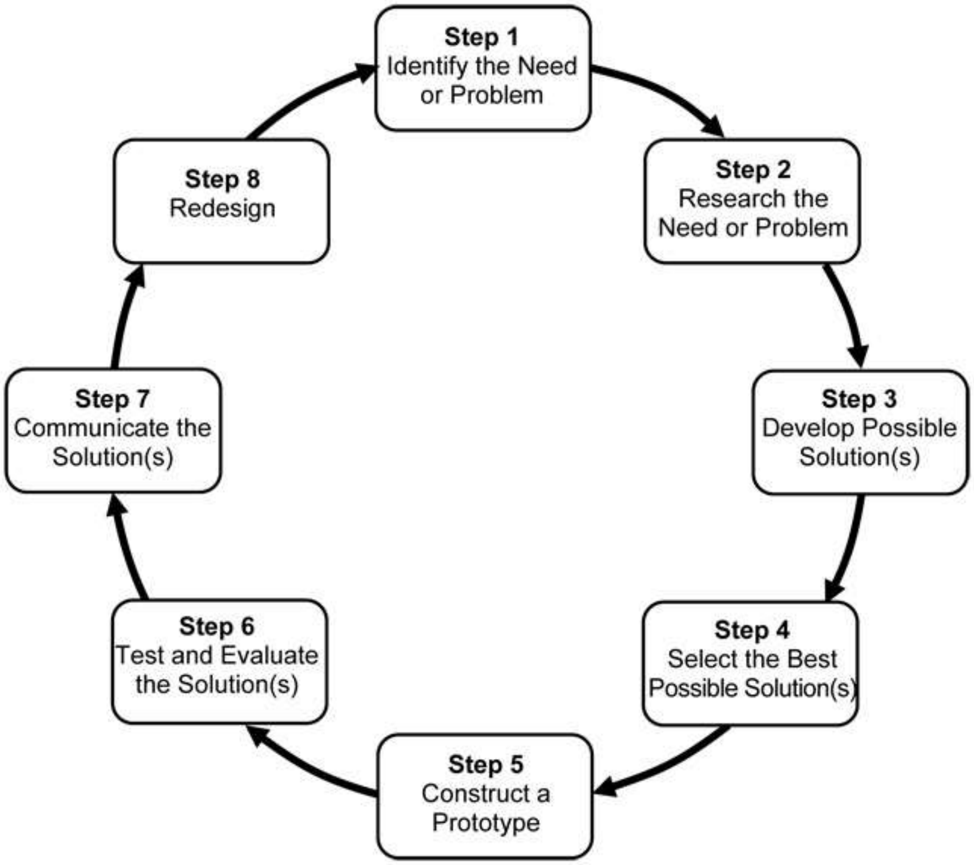


Figure 2-2 Depiction of the Engineering Design Process Model (Massachusetts Department of Education, nd).

2.5 4-H and Life Skill Learning Through Experiential and Inquiry Learning Models

In non-formal settings, such as the 4-H Youth Development Program, curriculum and learning experiences are designed around the Experiential Learning Model. According to the National 4-H Headquarters Fact Sheet (*Experimental learning: Fact sheet*, 2011) on Experiential Learning, it takes places when "youth are involved in an activity, looks back at it critically, determine what was useful or important to remember, and use the information to perform another activity" (p. 1). The process of Do-Reflect-Apply is the cornerstone of all 4-H curriculum and programs that are developed to reach youth where they are. This hands-on learning approach has also raised questions about how to teach more inquiry-based learning in STEM curricula as part of 4-H. This approach grows from 100+ years of learning in STEM through experiments and guidance of adults through hands-on activities dating back to corn clubs and canning clubs in the early 1900's. As described in her tools for the trade article, Virginia Bourdeau (Bourdeau, 2004) explains inquiry in 4-H as "informal learning environments are ideal settings for learners to practice skills necessary for scientific inquiry" (p. 1).

The 4-H Science Inquiry in Action Model (Bourdeau, 2004) is developed as a mentor/volunteer guide to expediting inquiry-based learning fused in the experiential process that takes the experiences that youth have in non-formal settings and compliments it with inquiry learning. This model is centered on giving volunteers the tools that they need to lead youth through an inquiry-based process in a non-formal learning environment (Bourdeau, 2004). The process of integrated inquiry learning into 4-H STEM experiences through volunteer and educator engagement, creates opportunities to engage youth in different learning styles to further growth of STEM programs in 4-H.

The integrated STEM inquiry model differs from a traditional inquiry model. The research presented from Bourdeau (2004) described the process of leading through the integrated inquiry model is similar to the study conducted by Marulcu and Barnett (2016) in which they examined the use of inquiry driven STEM models and engineering design driven STEM models (p.2). Their study analyzed the use of the two models in an elementary classroom and used both quantitative and qualitative methodology to compare the two groups of students that used two different curricula based on the two different models. In the study they found that using an engineering design curriculum increased the students' ability to reason and talk about their finding based on the interviews (Marulcu, Barnett, 2016, p. 5). They also found out that using inquiry-based learning students scored higher in the pre-post multiple choice and open-ended questions (Marulcu, Barnett, 2016, p. 5).

Using this study as a reference point, even though it was looked at in school engineering design curricula, it is noted that there is an opportunity to use an integrated curriculum that melds not only inquiry-based learning, but also engineering design process principles. This model falls in line with the integrating of inquiry and experiential learning but needs to be focused more on engineering design and less on open ended. The ability to merge these two models, and research within, would be able to link STEM education in an afterschool setting and 4-H learning models that are already used throughout the United States in the program.

The development of new and innovative 4-H STEM programs is an area that has been focused on since 2001, when the National 4-H Council created an initiative to ignite a passion in

STEM through new experiential and inquiry-based learning efforts. These efforts, like the 4-H Maker Movement (Hill, Peterson, & Francis, 2015), engage youth in an upcoming, innovative idea or program that engages them in science learning. The innovative approach to STEM learning through both inquiry and experiential learning models gave the youth in the Maker Movement projects in Utah a feeling of success and an interest trying new things (Hill et al., 2015). Similar to the research found in the Maker Movement study in Utah, it is important for programs and projects in 4-H to be developed through either experiential or inquiry-based learning approaches that develop STEM skills in youth. One need seen is that the amount of research like the Maker Movement study in 4-H is few and far between and this study will help with filling a gap in fluid power education in 4-H.

2.6 Experiential Learning

In Extension education, the words "experiential learning", are part of every learning situation and needs assessment that is created for outreach education. Experiential learning can be credited back to John Dewey as the core for using experience in educational learning as basis for education learning. From the work of Dewey, researchers such as David Kolb have created a breadth of research around experiential learning. The creation of educational models and theories that guide the development of programs, activities, and experiences to create learning in both adults and youth are instrumental in multiple facets. Kolbs experiential learning theory (ELT) has a base in research conducted by Dewey, Lewin, and Piaget (Kolb, Boyatzis, & Mainemelis, 1999). As Dewey et al., explains:

> the theory is called "experiential learning" to emphasize the central role that experience plays in the learning process, an emphasis that distinguishes ELT from other learning theories. The term experiential is used therefore to differentiate ELT both from cognitive learning theories, which tend to emphasize cognition over affect, and behavioral learning theories that deny any role for subjective experience in the learning process. (p. 21)

The use of the ELT, as well as the Learning Style Index, has been used across disciplines, but the largest use of the ELT is in the field of education (Kolb et al., 1999). According to Kolb et al. (1999), most of these studies are in higher education verses K-12 education and adult education. Since the focus of this study is on K-12 education, the focus on Kolb et al. for this thesis will be on the K-12 studies and implication of that realm of research. One of these implications found in Kolb et al. (1999) was “regarding integrated learning”.

> Integrated learning is conceptualized as an idealized learning cycle or spiral where the learner “touches all the bases” experiencing, reflecting, thinking, and acting in a recursive process that is responsive to the learning situation and what is being learned. (p.22)

This implication of integrated learning styles is congruent with the Experiential Learning Model that is adopted by the National Institute for Food and Agriculture (NIFA), Cooperative Extension Service (Extension) and the 4-H Youth Development Program (4-H). With respect to NIFA, 4-H, and Extension experiential learning is quietly woven into every extremity of the system. Enfield, Schmitt-McQuitty, and Smith in their research article The Development and Evaluation of Experiential Learning Workshops for 4-H Volunteers (2007) explain the use and the development of an experiential learning model for 4-H and Extension based on the work of Kolb and Pfeiffer and Jones. In the model that they use the experiential learning process is broken down to five cyclical aspects: experience, share, process, generalize, and apply, as shown in Figure 2-3.

This model is used to illustrate the experiential learning process in all educational curriculum that is produced as part of the National 4-H Cooperative Curriculum System. This model will also be the version of the experiential learning process that will be referred to through this research. This model, as described by Enfield et al., (2007) is used as the cornerstone for most educational experiences in the 4-H program nationally. For this research, experiential learning and inquiry learning modes will be investigated as well as the use of the engineering design process on Inquiry Based Learning.

Experiential learning is the most solidified learning model used in the Extension system, but inquiry-based learning is another model that is used within the Extension system and is most prominent within 4-H STEM programs. The breadth of work on inquiry-based learning is multifaceted. Scholars such as Bereiter and Scardamalia; Brandsfor, Brown and Cocking; and Sandoval and Reiser have all created research literature around inquiry-based learning in different settings (Blessinger & Cafora, learning for both experiential and inquiry-based learning 2014).

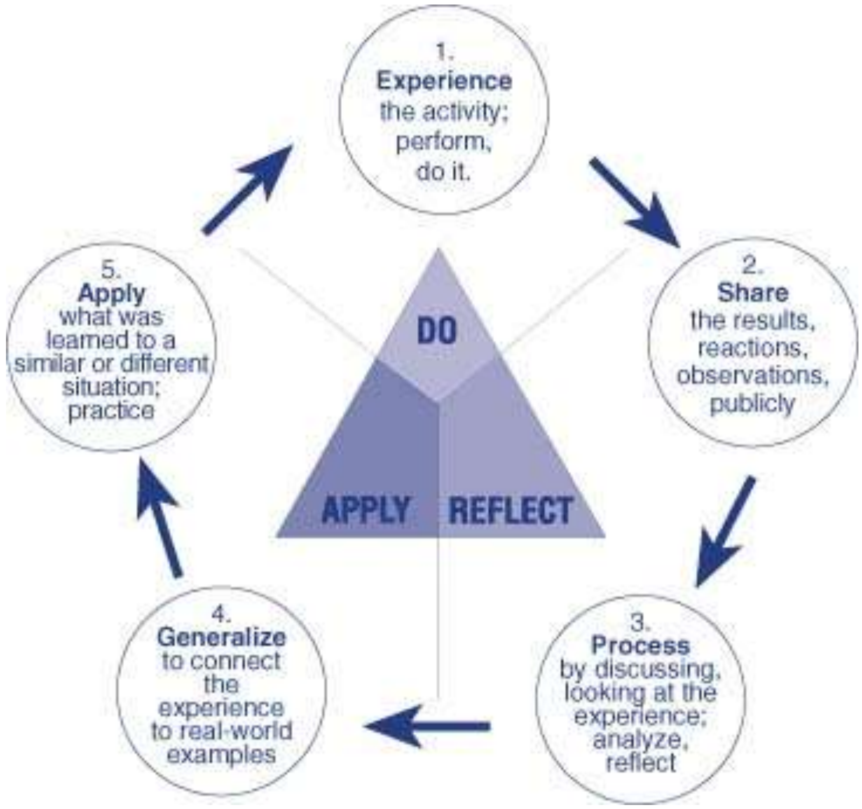


Figure 2-3 *5-Step Learning Cycle (Enfield et al., 2007).*

The book Inquiry Based Learning for the Arts, Humanities and Social Sciences by Blessinger and Carfora (2014) will be used to sum up the literature that is available as well as provide a definition for basis for inquiry-based learning. Blessinger and Carfora (2014) define inquiry-based learning as:

> an approach to enhance and transform the quality and effectiveness of the learning experience by adopting a learner-centered, learner-directed, and inquiry-oriented approach to learning that puts more control for learning with the learner. (p. 5)

Blessinger and Carfora (2014) also explain that during this style of learning the role of the facilitator is important in implementing an environment in multiple contexts that creates an ideal learning situation for the learner to take the lead in their learning experience. This is referred to as moving the instructor “from being an isolated subject matter expert to an instructional leader, learning architect, and learning guide and mentor” (Blessinger and Cafora 2014, p. 6). The other important part to consider in this form of learning is that both the individual and the mentor take on larger roles in the process, instead of a focus on the product (Blessinger & Cafora, 2014).

As defined by Blessinger and Carfora (2014),

> IBL holds great promise in developing more self-sufficient lifelong learners, but IBL can also present great new challenge for instructors and learners. (p. 8)

Unlike the Experiential Learning Model, the use of the Inquiry Based Learning model is not as prevalent in Extension and 4-H research. Bourdeau (2004) introduced a model for 4-H Science as Inquiry in her article 4-H Experiential Education-A Model for 4-H Science as Inquiry. Bourdeau (2004) builds on experiential learning as a basis for inquiry-based learning. To fit the needs of the Extension population she explains, "informal learning environments are ideal settings for learners to practice skills necessary for scientific inquiry" (Bourdeau, 2004).

Creating a model of inquiry learning that also meets the needs of experiential learning, creates a foundation to build upon for the Extension and 4-H communities. This model creates a training basis that can be implemented for volunteer and mentor audiences, as well as meet the definition of STEM literacy and STEM integration that were introduced before. In Blessinger and Carfora (2014), the audience leading the inquiry-based approach is normally a teacher or an educator, for the 4-H program, as explained in Bourdeau (2004) that person is most likely a volunteer who might or might not have formal education experience.

The ability to look at career aspirations in STEM through inquiry-based experiences is at the forefront of the discussion within 4-H. Dillivan and Dillivan (2014) found that using an inquiry-based approach to science learning in a non-formal setting "has particular value for future scientists because it exposes them to skill utilized in their careers" (p. 2). In their study "student interest in STEM disciplines: results from a summer day camp" Dillivan and Dillivan (2014) "sought to determine whether inquiry-based activities result in interest levels that are different relative to non-inquiry-based activities" (p. 3). Through this study they found that interest in inquiry-based activities was higher than those of non-inquiry-based activities, as well as that most parents who returned a post survey felt like their child showed an increased interest in science and that they would like for their child to pursue a career in science (Dillivan & Dillivan, 2014). This study lays a basis to continue to look at the approach of inquiry learning in science learning.

In Figure 2-5, the 4-H Science Inquiry in Action model shows the development of an inquiry-based model that also follows the experiential learning process. The continuation of research in using the 4-H Science Inquiry Action model for programs related to fluid power and engineering design is needed. The development of this model creates a starting place for training and resources for those volunteers, educators and mentors in 4-H Fluid Power.

2.7 4-H Learning

The National 4-H Learning Working Group (2016) introduced a learning process paper titled "The 4-H Learning Experience" (pg. 1). They define 4-H learning as "a multi-dimensional experience that integrates transformative relationship, learning environments, learning pathways, and learning outcomes" (The National 4-H Learning Working Group, 2016, p. 1). Figure 2-4 depicts the model that was developed to depict the framework. The framework relies on four different areas. The first area is transformative relationships. The National 4-H Learning working group explains this as "young people and adults learn together in 4-H; each person changing their self, other and the environment" (2016, p. 1). This is a building block of the programs and educational experiences that are part of the program.

The second area is learner practices. These are defined as: be well, be curious, and nurture a growth mindset (Working Group, 2016, p. 2). Each of these defines the principles in the learning practices for programs and activities implemented within 4-H. The third area is learning environment. The environment consists of a safe space, systems thinking, resources, social and culture (Working Group, 2016, p.3). The environment of learning is based on basic needs and the essential elements of 4-H. This area focuses on creating a learner centric environment where not only the learner feels safe but feels compelled to learn. The last area is learning pathways. This area consists of making the learning your own and use and share the learning with others (Working Group, 2016, p. 4). This section focuses on active involvement in learning as well as real-world application as part of the learning process.

The last section of the learning process is the learning outcomes. The National 4-H Learning Working Group states":

> 4-H learning experiences help youth find ways to achieve their goals and explore their purpose. 4-H programs emphasize supporting young people to take active roles in their own learning and growth across all domains of their life, expanding

> their capacity to achieve the success they want in life, and to thrive. (Working Group, 2016, p. 5)

This approach creates an opportunity to grow and learn through outcomes of knowledge, reasoning skills, motivation, disposition, identification and contribution. The approach to learning through the 4-H program is a holistic approach to learning and developing through a learner centric approach.

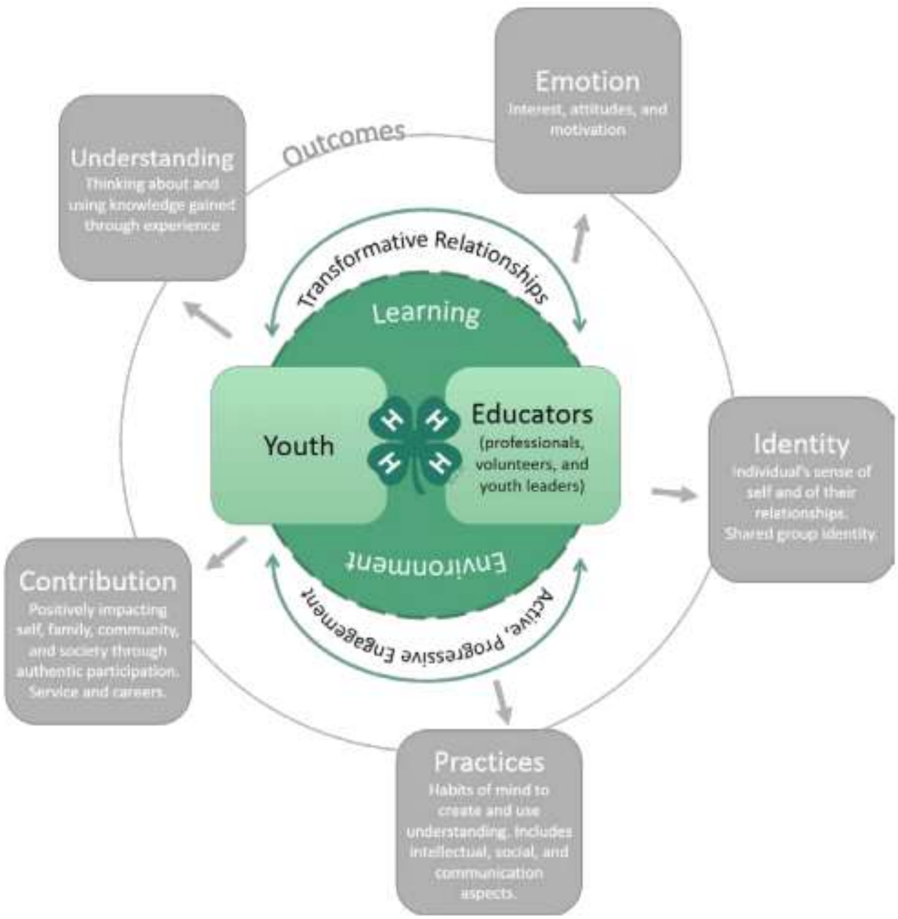


Figure 2-4 Depicts the 4-H Learning and Teaching Framework (Working Group, 2016).

2.8 Sustained 4-H Experience Through 4-H Ecosystem Approach

Sustained experiences in STEM education as part of non-formal learning are also another important concept as part of this study. Learning in non-formal settings were reviewed by Barker, Larson, and Krehbiel in their article "Bridging Formal and Informal Learning Environments" (Barker et al., 2014). In their research, Barker, Larson, and Krehbiel (2014) found that:

> effective OST programs should be student-centered, employ cooperative learning strategies, and foster skills and attitudes toward STEM through authentic, hands-on activities. (p. 2)

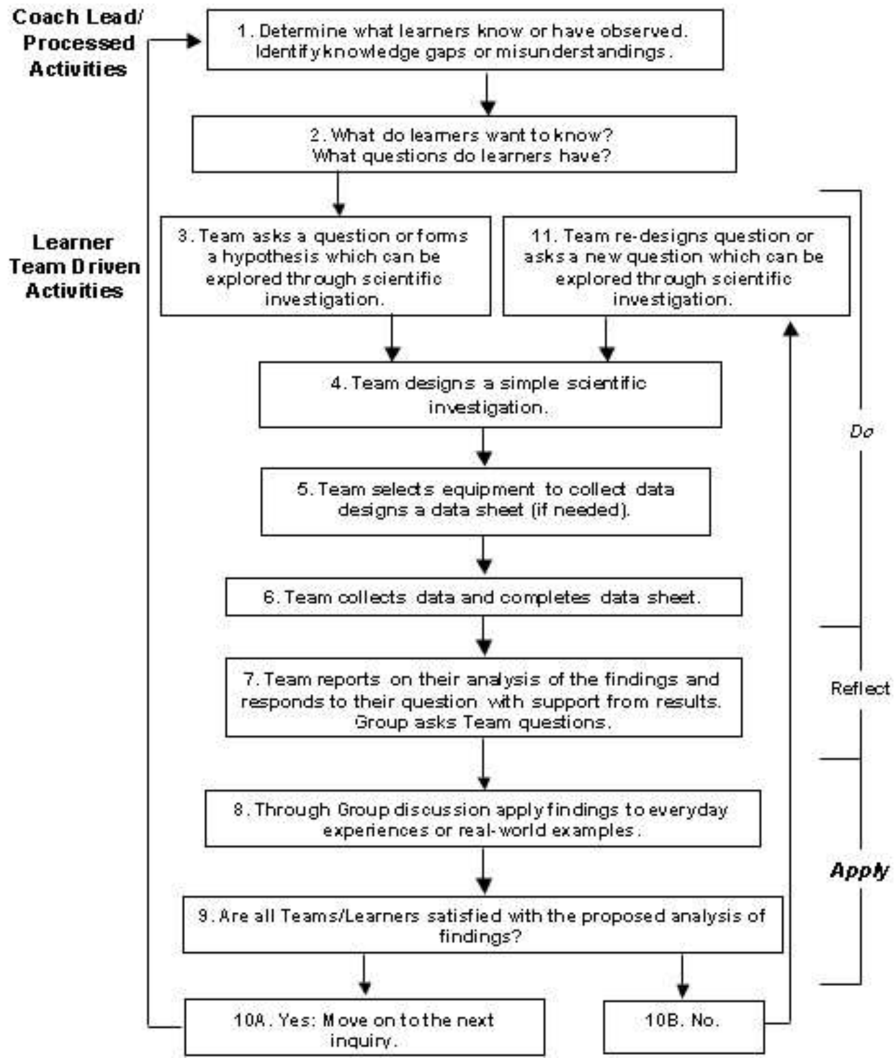


Figure 2-5 4-H Science Inquiry in Action (Bourdeaux,2004).

It is also indicated that one shortfall of non-formal programs is the fact that they do not always align with learning strategies and goals from in-school time for each child that participates (Barker et al., 2014). According to the NRC (Barker, Grandgenett, & Nugent, 2009) the differences in evaluation, learning strategies and measurement from formal to non-formal can be some of the challenges that are faced. Barker, Larson and Krehbiel (Barker et al., 2014) acknowledge the need, through examples of programs, to bridge the gap and to increase the richness and learning opportunities that are available for youth in both settings.

As Extension focuses on moving volunteers and 4-H Educators to understanding and increasing comfort levels with leading programs and 4-H experiences with inquiry-based learning model, it is important to understand the competency building that must be built with new volunteers and educators as well as existing volunteers as the base for youth learning competencies. Barker, Grandgenett and Nugent explain in “A New Model of 4-H Volunteer Development in Science, Engineering and Technology Programs” (2009) that the tradition of successful STEM programs has come with a different set of 4-H Volunteers than what has been seen in the 4-H program over history.

Even though more research needs to be completed in this area, which is one reason why studying perceptions is important, Barker, Grandgenett and Nugent (Barker et al., 2009) have developed a STEM specific training model that focuses on developing competencies through face-to-face training, on-line modules, monthly web meeting and self-directed learning. This model is developed so that STEM programs can be delivered less by 4-H Educators and more by 4-H Volunteers (Barker et al., 2009). This approach increases the sustained ability of experiences for youth who participate in these sustained learning experiences in STEM and fits in with the needs and understanding of the 4-H Fluid Power Program. This approach helps to continue to increase the ability to reach more youth with fluid power programs and to create a model that increases saturation in communities with STEM literacy and STEM learning.

2.9 Gender and Geographic Location and STEM

One factor that seems to be discussed thoroughly in the STEM arena is gender and interest in STEM. Gender is a discussion within STEM because of the unequal proportions of men to women in STEM career fields. According to the Bureau of Labor Statistics in their report “STEM Occupations: Past, Present, and Future (2017) “of 100 STEM jobs, 93% had wages above the national average” (Fayer, Lacey, Watson, 2017). This wage is nearly double the wage of non-STEM jobs according to the survey by the Bureau of Labor Statistics (Fayer et al., 2017). The market for STEM jobs is not just focused around a higher average salary, but also the growth of STEM jobs between 2009 and 2015 increased double that of non-STEM jobs.

With so many jobs, why is it that only a small percentage of those jobs are filled by females? Microsoft conducted a study of 11,500 girls across Europe to find that most girls in middle school were interested in STEM careers, but by high school over three-fourths of the same group of girls, were no longer interested in STEM careers (Choney, 2017). Similarly, the U.S. Department of Commerce in their report "Women in STEM: 2017 Update" state the following key findings:

- Women filled 47 percent of all U.S. jobs in 2015 but held only 24 percent of STEM jobs. Likewise, women constitute slightly more than half of college educated workers but make up only 25 percent of college educated STEM workers.
- Women with STEM jobs earned 35 percent more than comparable women in non-STEM jobs — even higher than the 30 percent STEM premium for men. As a result, the gender wage gap is smaller in STEM jobs than in non-STEM jobs. Women with STEM jobs also earned 40 percent more than men with non-STEM jobs.
- While nearly as many women hold undergraduate degrees as men overall, they make up only about 30 percent of all STEM degree holders. Women make up a disproportionately low share of degree holders in all STEM fields, particularly engineering.
- Women with STEM degrees are less likely than their male counterparts to work in a STEM occupation; they are more likely to work in education or healthcare (Noonan, ESA Issue Brief #06-17, 2017).

The debate on why the gap exists is attributed to many different factors. "Some analysts assert that self-efficacy, institutional culture, discrimination, and bias limit female participation in science" (Gonzalez, Kuenzi, 2012). The gap between male and female is a studied gap, but one need is to study why and how development of programs and participation in these programs affect youth based on gender.

Geographic location, like gender, is another factor that is important to consider for youth participants. Geographic location can be defined in different ways, but for this purpose the definition will be the area of the state in which youth reside, based on the type of development in the area. Labels for this will be urban, suburban, town, rural non-farm, and farm. In Chapter 4, the variables will be more closely defined. Pam Burress, in her article "Closing STEM Education Opportunity Gaps for Rural Students" (2017) discusses the gap that is present for rural youth both in school and out of school.

One of the issues facing out of school time is "access to rich STEM learning experiences after school" (Burress, 2017). Burress discusses that even though some of the more popular

STEM opportunities that are focused more in urban settings, like museums and maker spaces, other experiences such as 4-H, FFA, parks, farms and forests do exist in rural areas with opportunities to teach STEM (2017). According to Burress "the challenge" is to connect students with these opportunities" (2017). Deborah Yaffe, in her article "Small-town STEM: Rural districts bolster math and science programs with new funding sources, technology and powerful partnerships" echoes the same sentiment that when thinking about rural programs, a different perspective is needed than urban needs, especially with regards to technology and access with youth being spread-out a larger distance than in urban areas (Yaffe, 2018).

As broken down for the rural setting, the geographic location comes down to access and technology opportunities that are available. The same issues could be in place for urban settings depending on access and technology available to the particular area in the urban setting. Which makes the opportunity to look at outcomes based on geographic location a necessary and needed area to determine based on.

2.10 Conclusion

Through the review of literature, it is apparent of the breadth of literature that is available for experiential learning, integrated STEM education, and STEM program development. This basis of literature helps to lay a foundation for creating research in the areas of fluid power education, and even can serve as a model for other specific areas of STEM. Even though research is abundant in these areas, the ability to link this research directly together in any area of engineering education within 4-H, or other out of school time-based youth programs has not yet been created. With this study, an opportunity exists to create research and learning around this area that can directly influence how programs are created and delivered within 4-H fluid power programs.

The National Fluid Power Association (2018) in their PowerPoint presentation of the workforce survey that they conducted with their members across the United States points out a few different key facts that are important to understand from the literature and information that is obtained about moving forward. The survey detected that of the companies that responded over 60% responded that their current work force is slightly lacking for higher of skills areas in "understanding the benefits of fluid power" and "applying design, simulation, and analysis tools to fluid power" (p.7). John Savage in "How Competent is your Workforce" also expressed similar arguments from the National

Fluid Power Centre in the United Kingdom (2016). He expresses the need to increase skill development for employees prior to entering the workforce. Both areas lay the base work for why it is important to continue to develop research and education around this area.

One common thread throughout this entire literature review is the lack of research in fluid power education, especially in a non-formal K-12 setting. A need is identified in this area, as well as using a structure of inquiry-based learning to create STEM experiences in 4-H. The ability to use this study to create a base line of research in K-12 education based around a STEM skill focus will be valuable to continue to build upon in the future, for both researchers and practitioners. The literature review also pointed out the need to focus in on modes of delivery for training for adults working within the fluid power education.

CHAPTER 3. EDUCATIONAL PROCEDURE

3.1 Introduction

The 4-H Fluid Power NFPA Challenge is designed as an educational experience for youth in grades sixth through eighth during which they participate in both an on campus six-hour workshop experience as well as self-regulated learning for six weeks. This annual event concludes with a six-hour challenge day in which students use designs, portfolios and prototypes to build a device to complete a specific task. Youth participate in teams of three to five youth. Youth may participate for up to three years in the competition. Each year the process is similar, but the challenge tasks change for competition day.

One important aspect of creating the learning experience for this program, is to understand and be mindful of the different learning styles that will impact the participants at all stages of development and implementation. Different models can be used to outline what this looks like in a learning space. One of these models is the genesis model (Moser, 2016). This model is designed to look at the "confrontation of the learning material" (Moser, 2016) and how the flow of this information and interactions influences the learning style for each individual child. Figure 3-1 show the genesis model explained by Moser in the article "Exploring the development and impact of learning styles: An empirical investigation based on explicit and implicit measures" (2016).

Within 4-H youth development there are a variety of delivery modes that can be used to reach youth. These delivery modes consist of 4-H clubs, specialty 4-H clubs in one subject matter, after school 4-H clubs, school enrichment experiences (which is less than six hours, in-school clubs (lasting more than six hours), short term 4-H experiences in one subject matter (such as SPIN or SPARK clubs) and education experiences. (4-H, 2018). All delivery modes are a minimum of six hours as a definition of educational program through National 4-H Headquarters. Educational experiences are those less than six hours in length and focused on one subject matter.

Sharon Kinsey in her 2013 journal article titled "Using multiple youth programming delivery modes to drive the development of social capital in 4-H participants" breaks down the different types of delivery modes within 4-H and how each delivery mode increases social capital in youth (p. 61-64). This method gives us the basis for this program, as the delivery mode for the 4-H Fluid Power Program and a basis for how the program is organized. The program centers around SPIN or SPARK club experiences, but depending on the need of the county, spans 4-H Club experience, SPIN/SPARK experience, after school club and school enrichment. It also reaches outside of 4-H and brings in other school-based programs as the delivery mode. Understanding the versatility of delivery modes for the 4-H Fluid Power Challenge, gives an understanding of the program that is being evaluated. Throughout this chapter the 4-H Fluid Power Challenge program will be further described and defined.

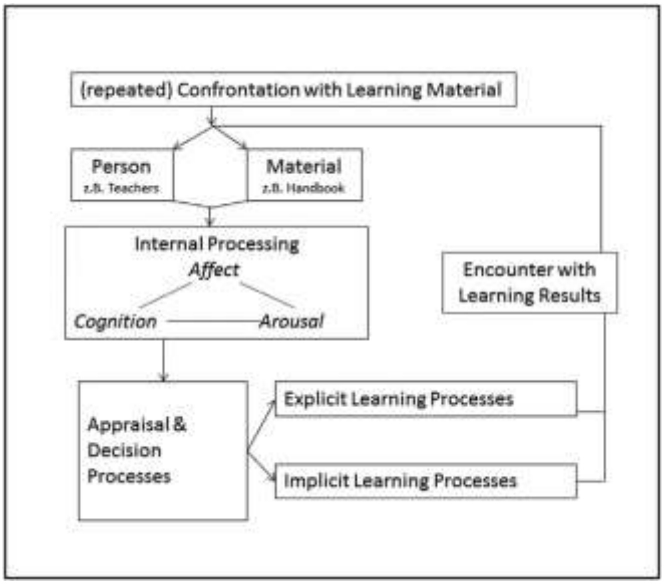


Figure 3-1 *"Learning Styles in Genesis Model" (Moser, 2018, 148).*

3.2 Fluid Power Workshop

The fluid power workshop day is comprised of instruction, hands-on activities, and group-based learning. Teams arrive at the campus location at 9:30 a.m. in the morning on workshop day. During this time teams are registered and given general instructions and room assignments for their first session. Before starting the workshop, team members complete a pre-survey. The agenda for workshop day, as seen in figure 3.2, is used to build on both a college style lecture opportunity as well as hands-on learning around engineering and design principles.

The collection of the data for the research study was conducted during both the workshop day and the challenge day for this program. Two surveys were used as the instrument for collection, the 4-H Fluid Power Survey and 4-H Common measures. The 4-H fluid power survey was administered before the first session of the workshop day. Youth were given the choice to participate, and participation in the survey did not affect their participation in the challenge. The 4-H Common Measure and 4-H Fluid Power post-test survey were used after the completion of building their machine and before the actual competition on workshop day. Youth were given the choice to complete the survey, and completing the survey had no effect on their challenge scores.

During the workshop day, teams are divided into session teams of three to four teams to rotate between two different activities: "Engineering Design and Fluid Power" and "Basics of Fluid Power Learning and the NFPA Fluid Power Context". During the first session half of the teams attend a classroom style lecture to get instructions and learn about the objectives for the day. This is also where they learn about the concepts of fluid power and applications, as well as learn about the objectives, goals, and template for the Fluid Power Challenge. This portion is designed to be given in a university lecture classroom to give youth a more focused and scholarly preparatory experience.

9:30 a.m.	**Teams Arrive and register**
10:00 a.m.	**Welcome, Introductions**
10:15 a.m.	**Group A: Introduction to Fluid Power Technology, Design and Portfolio Strategies, Challenge Competition** **Group B: Engineering Design with Fluid Power- Building and Designing devices for a purpose- Hands on Activities**
11:00 a.m.	**Group B: Introduction to Fluid Power Technology, Design and Portfolio Strategies, Challenge Competition** **Group A: Engineering Design with Fluid Power- Building and Designing devices for a purpose- Hands on Activities**
12:00 p.m.	**Pizza Party**
12:30 p.m.	**Tinker with Kits!** **Build Pneumatic Lifter & Rotator**
2:30	**Clean up and Wrap Up**

Figure 3-2 *4-H NFPA Fluid Power Challenge Workshop Day Agenda*

The other half of the teams participate in hands-on learning activities in engineering design and basics of fluid power mechanics. They are given instructions as well as assistance from graduate student facilitators but use a "learn by doing" (Indiana 4-H, 2017) process to build a pneumatic lifter in each breakout room hosted in the on-campus labs. A total of three to four teams are in each of the breakout classrooms. The session teams switch after the end of one hour.

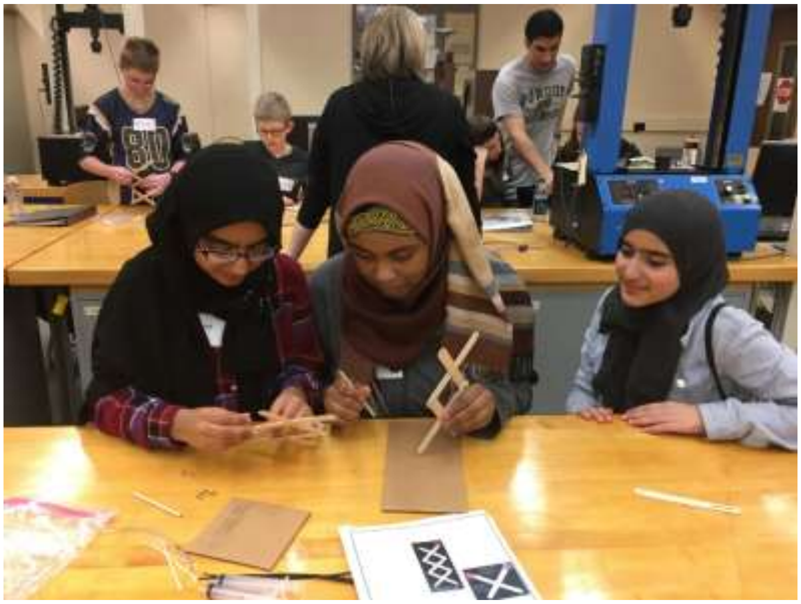


Figure 3-3 A team participates in building a fluid power elevator during workshop day

In the afternoon, teams focus on learning how to build a lifter and rotator that will be the base of their competition design in their breakout classrooms. Teams work with facilitators in each of the breakout rooms to create a lifter that serves as the basic building blocks of learning for the teams' machines that they will build as a prototype. Materials in their workshop day kit reflect the materials needed to build the lifter. Each team is given instructions for the lifter (Appendix A). Teams work with each other, their mentor, and group facilitators to complete this task. The building of the lifter requires teams to learn to measure, use a saw, and use a hand drill. They also are briefed on safety and tool usage before building the lifter by the room facilitators. This focus has youth working as a team, as well as starting to set goals for learning during the six-week process. Workshop day consists of six hours of instruction. Figure 3-3 depicts one of the many hands-on learning activities that take place during workshop day.

The critical portion of this program is when youth return to their communities across Indiana and work with their volunteer or mentor coach to create a prototype of the machine that they will use on workshop day. Volunteers or mentors range from teachers, to 4-H club leaders, to community members with an interest in STEM, as well as parents. Teams receive a workshop kit and a tool kit in which they can take home with them to work with during the six weeks in between (Figure 3-4).

The teams use this kit to create a prototype of the machine that they will build on challenge day. During the time in between, the most important tasks are that they created the prototype and portfolio. Each team is given a task list to accomplish to help guide their process in between (Appendix A). The list serves as a guide and an overview for their team goals during the time. Teams are also given portfolio check list (Appendix A), a guideline for isometric and orthographic drawings (Figure 3-5) and challenge overview (Figure 3-7). Teams also receive a mid-term check (Appendix A) list that is not turned into organizers but is instead a guiding document that is used for time management. Coaches can use this list to help create learning objectives for youth during the process.

Figure 3-4 The workshop kit contents that students use to rebuild the machine on challenge day

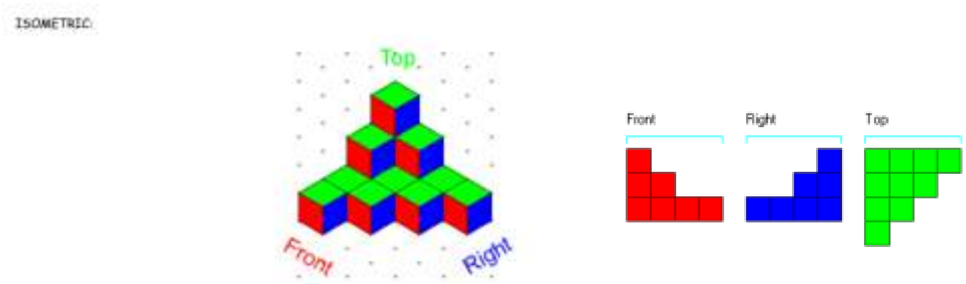
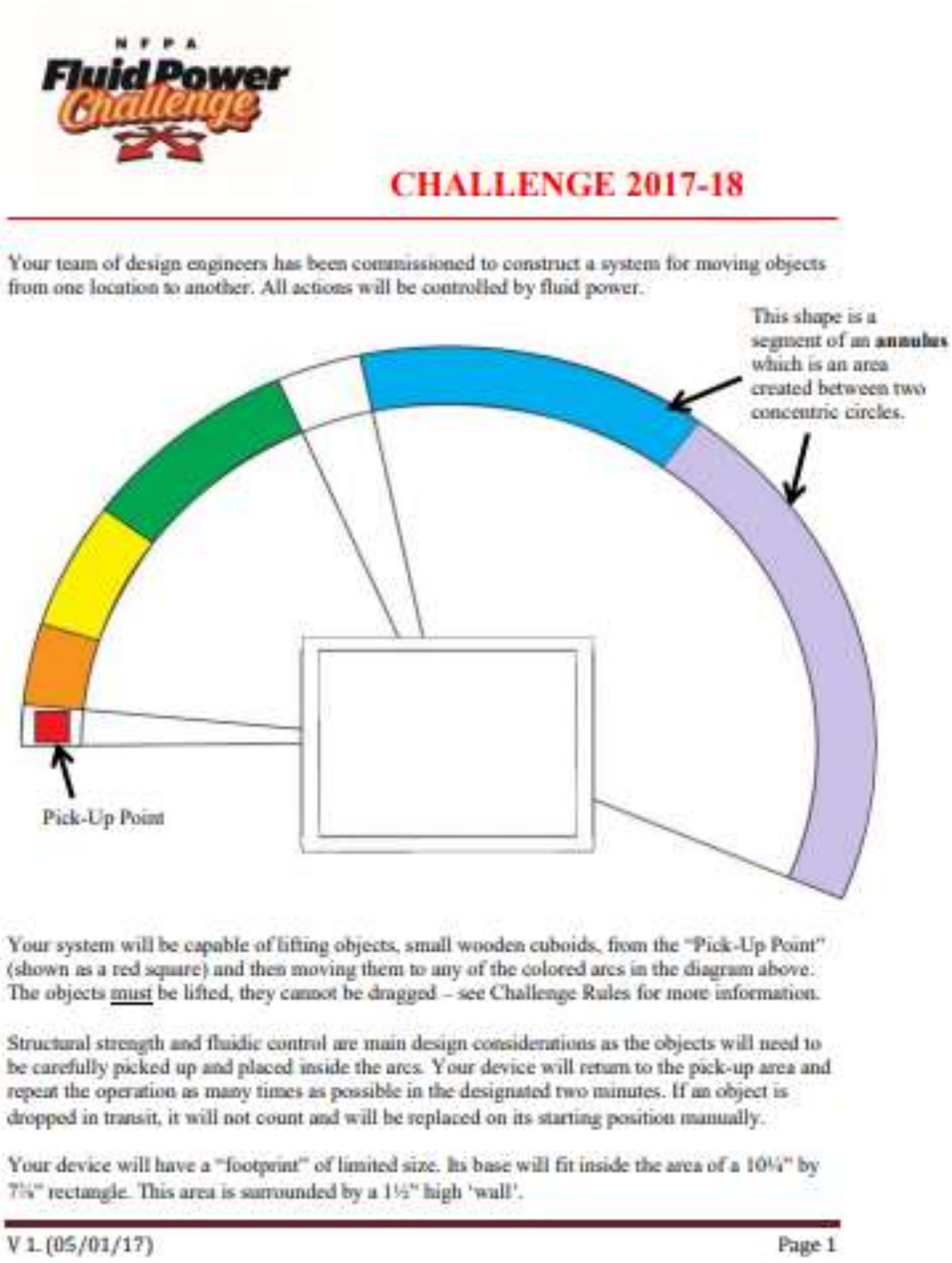


Figure 3-5 Depicts isometric and orthographic drawing examples for teams to follow

The second time the teams come together is for challenge day. During this day, each team returns to the classroom that they worked in previously. They spend three hours building a device like the prototype that was created during the six weeks between the two dates (Appendix A). They are given the same kit, now titled Challenge Kit. During this time, each team will answer interview questions with a judge, in an informal process (Figure 3-6). They will also have their portfolio graded by another judge, as well as be observed for teamwork and cooperation as part of overall competition.

These are part of the rubric for the competition. The day ends as they compete in the challenge and are judged on the number of points earned as well as design of their device (Appendix A). Teams are judged not only on how they complete the task, but device design, teamwork, interview and portfolio. Each section of the criteria is equally weighted. Each category also has a winner that is recognized. Teams are recognized for their hard work with certificates during an awards ceremony at the end of the day.

Figure 3-6 *Youth show their device design to judges during 4-H NFPA Fluid Power Challenge*



NFPA Fluid Power Challenge

CHALLENGE 2017-18

Your team of design engineers has been commissioned to construct a system for moving objects from one location to another. All actions will be controlled by fluid power.

Your system will be capable of lifting objects, small wooden cuboids, from the "Pick-Up Point" (shown as a red square) and then moving them to any of the colored arcs in the diagram above. The objects must be lifted, they cannot be dragged – see Challenge Rules for more information.

Structural strength and fluidic control are main design considerations as the objects will need to be carefully picked up and placed inside the arcs. Your device will return to the pick-up area and repeat the operation as many times as possible in the designated two minutes. If an object is dropped in transit, it will not count and will be replaced on its starting position manually.

Your device will have a "footprint" of limited size. Its base will fit inside the area of a 10¼" by 7¼" rectangle. This area is surrounded by a 1½" high 'wall'.

V 1. (05/01/17) Page 1

Figure 3-7 *Explanation of the rules for the challenge scenario*

CHAPTER 4. METHODS

4.1 Introduction

This research study is modeled to create an opportunity to capture perceptions, interest, and motivation for youth in STEM through the Indiana 4-H Fluid Power Action Challenge. The study uses an already established event to collect data, and youth participation is not completely random. A correlational design will be used for this experiment. “A correlational design explores the relationship between variables using statistical analyses. However, it does not look for cause and effect and therefore, is also mostly observational in terms of data collection” (“Quantitative Approaches,” 2018). The methodology of this study is designed with a pre-post survey and post only survey. In this chapter the context of the study and participants will be defined. The measures used in the study as well as the procedure and data analysis will also be detailed in this chapter to lay out an understanding of the experimental design and methodology used for this study.

Correlational design or in some cases called descriptive correlational design (Lappe, 2000) is designed around relationships between variables. Joan Lappe in her article “Taking the Mystery Out of Research: Descriptive Correlational Design” discusses the positives and the negatives of using a correlational design for a research-based study in education. Her description of what a correlational design is described by the following:

> The aim of descriptive correlational research is to describe the relationship among variables rather than to infer cause and effect relationships. Descriptive correlational studies are useful for describing now one phenomenon is related to another in situations where the researcher has no control over the independent variables, the variables that are believed to cause or influence the dependent or outcome variable (p. 1).

This design lends itself to evaluating educational programs that are not fully in the researcher’s control. Even though it is not the most stringent research design with the least amount of possible bias, it is a research design that can create relationships between variables and look at at how those relationships benefit learning in an educational setting.

It is also important that in this research area that the disadvantages of this research design are also discussed for the understanding of the issues that could create any rigor or validity issues as discussed in further sections of this study. Lappe defines the disadvantages of this research design as:

> The major disadvantage of descriptive correlational research is its inability to reveal causal relationships. Another problem is that such studies are subject to faulty interpretation. Since participants in these studies are not randomly assigned to study groups, we cannot assume that they are similar in respect to traits other than those we are studying. Thus, findings that the independent and dependent variables are correlated may actually indicate that both of those variables are correlated with a third variable that we have not measured (p. 2).

Even though this is a concern, as stated in the limitations of this study, the fact that youth were given the opportunity to choose the activity created an understanding that in some way youth have at least one similarity which created the opportunity for correlation to create relevance.

4.2 Participants

The 4-H NFPA Fluid Power Action Challenge is a program designed by the National Fluid Power Association to introduce youth to the principles and a general understanding of engineering design and fluid power education. For this contest fluid power education is defined as the use of hydraulics and pneumatics. The nationally recognized event is targeted towards eighth grade youth in a school setting. In Indiana the 4-H NFPA Fluid Power program is designed to target youth in grades sixth through eighth grade and be held in an out of school time setting using volunteers, parents and teachers as mentors for teams of youth.

An average of 75 students participate each year in the 4-H NFPA Fluid Power Challenge for the past three years. Youth who participated were in the sixth through eighth grade ranging in ages from 12 to 14 years old. Approximately 40% of the students who participate have participated in the challenge in a previous year. Sixty percent of youth who attend are from a rural area, while 40% percent live in a suburban or urban area. For this survey rural is defined by populations as farm (identified through the Indiana Department of Agriculture (ISDA)), non-farm rural (less than 10,000), and town (10,000-50,000). Urban is defined as suburb of a city and city, which are both defined at greater than a population of 50,000. An average of 38% of youth who participate identify as female with 62% identifying as male.

The 4-H NFPA Fluid Power Challenge has been offered as part of Indiana 4-H since 2015. Youth participation is based on interest and is not limited to just 4-H members in the state of Indiana. The higher rate of rural program members links to a great presence of the 4-H program in rural communities in Indiana. Even though an equal presence is available in urban communities, the competition for youth and a higher amount of youth programs, can make recruiting youth for programs more difficult in urban communities than in rural.

The size of the sample were youth participating in the 4-H NFPA Fluid Power Challenge in 2018. This size varied slightly between workshop day and challenge day because of scheduling conflicts, change in plans, and groups dropping out. Seventy-five youth, in 18 teams, registered to participate and attend workshop day with 59 of the youth completing a pretest survey. The completion rate for pre-test survey was 79%. Between workshop and competition day, one team and ten total youth dropped out. On competition day 66 youth on 17 teams participated. Of the 65, 43 completed surveys for 65% completion rate for the post-test survey. The n=59 was collected during the workshop day for pretest surveys. A n=43 was collected on challenge day for the posttest. The second survey that was administered is the 4-H Common Science Measures 4^{th}-7^{th} grade survey (4-H Common Measures). An n=42 will be used for this survey. As 42 of the 66 challenge day participants completed the survey for a completion percentage of 64%. Figure 4-1 displays the frequency of pre and post-tests collected for the 4-H Fluid Power Challenge.

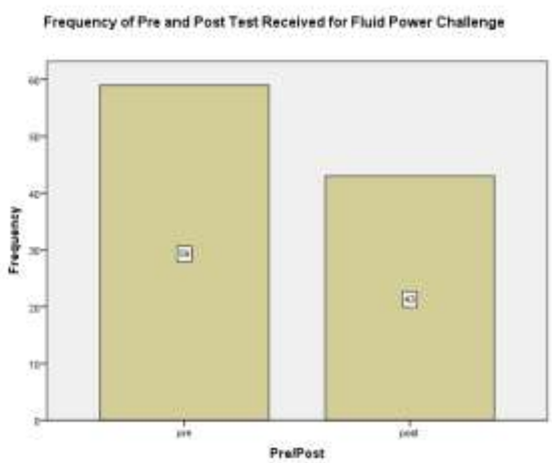


Figure 4-1 Frequency of pre and posttests collected

Table 4-1 Table 4-2 *Survey collections number for a three year period for the 4-H Fluid Power Challenge.*

Survey	Year	Participated	Survey Completion	Completion Percentage
4-H Fluid Power Survey- Pre	2016	98	74	76%
4-H Fluid Power Survey- Post	2016	83	74	89%
4-H Common Measures	2016	83	72	87%
4-H Fluid Power Survey- Pre	2017	72	48	67%
4-H Fluid Power Survey- Post	2017	63	39	62%
4-H Common Measures	2017	63	50	79%
4-H Fluid Power Survey- Pre	2018	75	59	79%
4-H Fluid Power Survey- Post	2018	66	43	65%
4-H Common Measures	2018	66	42	64%

4.3 Data Collection Method

The opportunity to examine and expand on the experience of youth who participate in the 4-H NFPA Fluid Power Action Challenge opened up an opportunity to collect data through quantitative surveys using two different survey instruments. Pre-post assessment, and post-assessment only were conducted. A comparison for the fluid power survey was conducted of data taken before and after the program. Youth participants voluntarily completed each of the surveys and had the option to not complete the survey. The completion of any of the surveys did not affect the outcome of the challenge or judging of the participation as part of the competition. The election to choose to complete the survey, along with youth who dropped out before challenge day, created a gap in between pre and post surveys

Pre-test-post-test design is designed to measure before and after the application of a “treatment” (Price, Jhangiani, Chiang, 2015). This design uses the pretest as the “control” group and the posttest as the treatment group and a comparison is completed between the two tests, using the same group (Price, et al, 2015). For an educational program, in which the ability to have a control group is limited, this design gives an opportunity to look at before and after the program implementation (treatment). Price et al (2015) outline a few issues with this type of design such as history, maturation, and regression of the mean which can all be seen as reasons why the change has happened for the program (p. 8).

The use of the Likert scale in this research study is part of two different survey instruments. Two different Likert scales are used. The first is a four-point Likert scale (4-H Common Measures) going from Strongly disagree to Strongly agree. The second is a five-point

Likert scale (4-H Fluid Power) going from Not at all to Very much. The Likert scale is named after Renis Likert an American psychologist (Chyung, Roberts, Swanson, Hankinson, 2017). The scale was developed in the 1930's to assess attitudes (Chyung, et al., 2017). One of the important parts of using a Likert scale is the definition of the type of scale that it is as part of the research project. Depending on the statistics being ran and the type of answer that is being looked at for this scale the choice between ordinal or interval needs to be made. Since this survey is looking for a quantitative mean from the data, the use of numbers and interval will be used.

The other discussion that needed to be made with Likert scales was data analysis. In a 2012 Journal of Extension Article, Boone and Boone discuss the difference between Likert type scale data and Likert scale data (Boone, Boone, 2012). The main difference is the number of items that are used to determine the significance through a mean. For example, Likert type data might be just one question, but Likert scale data is addressing more than one question (typically between three and four) (Boone, Boone, 2012). This inference continues to interpret data through statistical means, but for Likert type data used median, mode, frequency versus mean and standard deviation (Boone, Boone, 2012). This changed the analysis on question number one, based on the use of one question instead of a series of questions. This will also turn the analysis from interval to ordinal (Boone, Boone, 2012). Duncan and Stenbeck (2012) make the point that because of the differences in scales and references to those scale, it is important that each scale is validated individually, not based on a larger since of Likert scaling (p. 19).

The 4-H Fluid Power Survey was designed to capture fluid power specific information, and was designed based on the concepts of fluid power and STEM. The survey (Figure 4.2) details the information needed to capture both pre and post perceptions of youth who participated in the 4-H Fluid Power Challenge. 4-H Common measures is a national survey that was developed through National 4-H Council and USDA (Lewis, et. Al, 2015). The 4-H Common Measure Science survey is developed as post-test only survey. The survey has two different sections that measure STEM. The first measures attitudes and interest (Figure 4.3) and the second measured skills and application. The skills and interest uses a four-point interval scale (Tuckman, 1999) and the second uses a yes or no nominal scale (Tuckman, 1999).

Fluid Power Challenge Survey

This competition invites students to solve a real-life engineering problem using fluid power (hydraulic and pneumatic) technology. Fluid power is the ability to move large or heavy objects using compressed fluid or air. Please fill out the survey on what you knew before and what you have learned from this event.

1. Please answer each of the questions below based on your experience before and after the 4-H NFPA Fluid Power Challenge.

Scale: 1=Not at all 2=Not much 3=Somewhat 4=Pretty Much 5=Very

	Before doing the challenge				
Engineers are problem-solvers. How motivated are you to learn how to think like an engineer?	1	2	3	4	5
Do you believe that teamwork is an important skill to develop for your future?	1	2	3	4	5
Which of these words make you think of being an engineer? (circle all that apply)	IMPROVE MANAGE	FIX IDENTIFY	GIVE UP MEDICATE	CHOOSE IGNORE	
How interested are you in a career in science, technology, engineering and mathematics?	1	2	3	4	5
Name four ways that fluid power is used?	1. ________ 2. ________ 3. ________ 4. ________				
I am interested in learning more about fluid power and how it works.	1	2	3	4	5
I am interested in a career in fluid power or robotics.	1	2	3	4	5

2. List four of your favorite things about the Fluid Power Challenge Competition
   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________

3. How many years have you taken part in the 4-H Fluid Power Challenge? ____________
4. What is your gender? ______________________

Figure 4-2 *Displays the Fluid Power Challenge interest pre-post survey.*

Section II: Interest, Engagement, and Attitudes

4. **Please indicate to what extent you agree or disagree that your experience in this 4-H program or project has resulted in the following outcomes.** (Select one response in each row by marking the appropriate box ☒.)

In this 4-H program or project...	*Strongly Agree*	*Agree*	*Disagree*	*Strongly Disagree*
I like to see how things are made or invented	☐	☐	☐	☐
I like experimenting and testing ideas	☐	☐	☐	☐
I get excited about new discoveries	☐	☐	☐	☐
I want to learn more about science	☐	☐	☐	☐
I like science	☐	☐	☐	☐
I am good at science	☐	☐	☐	☐
I would like to have a job related to science	☐	☐	☐	☐
I do science activities that are not for school	☐	☐	☐	☐

Figure 4-3 *Interest, Engagement and Attitudes section of the 4-H Common Measures Science 4-7th grade survey*

4.4 Procedures

This study was conducted as part of the Indiana 4-H NFPA Fluid Power Action Challenge. The Indiana 4-H NFPA Fluid Power Action Challenge is a series of two events, a workshop day and challenge day. Workshop Day consists of introduction to what the fluid power challenge is, learning about fluid power and how it is used in both every day and industry, as well as learning basic construction of a lifter with either hydraulics or pneumatics. Teams of three to five youth in grades 6th through 8th grades work together on this project to capitalize on each group members strengths.

The Fluid Power Pre- Survey is given to each student to complete before the first session begins. They receive this survey during registration and given an opportunity to complete it without rushing before the general session starts. Youth are given pencils if they are needed. Surveys are returned to facilitators in each of the break-out rooms as well as can be returned at the registration table. All surveys are collected before the start of the workshop. The post-test survey and the post-test only survey will be administered at the end of the program once teams complete their projects. Both the post-test and post-test only surveys will be administered at the same time.

Ex post facto research gives an opportunity to look at events, programs, and pre-collected data that might not have been identified for research prior (Simon, M.K., Goes, J., 2013). The research design uses the opportunity to study areas in which a true experimental design is not possible (Simon, Goes, 2013). In educational research, this is a fit quite more often than in experimental sciences research. The ability to research a program or situation, without having a control group gives an opportunity to continue to build on research based on programmatic and other educational successes. Simon and Goes (2013) further explain that this type of research, which is more common in the social sciences, still has strong ties to experimental design through inquiry-based procedures. Simon and Goes (2013) also outline the limitations of ex post facto research:

- There is no random assignment to treatment so there could be inherent confounds in the variables studied.
- The sample cannot be considered random, so generalization is limited
- There is often little information about any dropouts from the treatment (p. 2).

By selecting ex post facto research design for this study, the benefit offsets the limitations for this study. The use of the ex post facto study gives the best design format to answer the questions that this research study is asking. The study uses one major design within this style, correlational study. The correlational study is when “a researcher collects two or more sets of data from a group of subjects for analysis that attempts to determine the relationship between them” (Tuckman, 1999, p. 181). The use of this design will create a correlational link between a variety of different variables that will be collected through both surveys (Tuckman, 1999). These variable relationships that will be looked at are interest in fluid power and gender, attitude toward STEM and gender, attitude toward STEM and geographic location, STEM skills and gender, and STEM career interest and gender.

4.5 Data Analysis Method

As noted in the measures and procedure section data will be collected from two different types of survey, a pre and posttest only. Specific questions from the data set will be used to answer the three research questions that were outlined in the introduction. Those questions are:

RQ1. How does participation in the 4-H Fluid Power Experience increase interest in STEM careers for participants?

RQ2. How does participation in the 4-H Fluid Power Experience improves attitudes about STEM?

RQ3. How does participation in the 4-H Fluid Power Experience influence positive attitudes about fluid power?

For each research question a certain subset of data questions from one of the two surveys is linked to those research questions. Each question also has one or more hypothesis that is affiliated with it. In this section, a correlation will be looked at between the data being analyzed and the three research questions, as well as establish the questions that are affiliated with each research questions and what is being analyzed. The data analysis procedure and tests will also be discussed in this section.

The data analysis that will be done for this study was conducted in the form of two different statistical tests that will be run through SPSS software. SPSS was chosen because of its ease of use and ability to run educational statistical tests. SPSS, which stands for Statistical Software for Social Sciences, creates a variety of tests that are used in educational research. The use of the SPSS software gives easy access to mathematical calculations without the work associated with those tests (Bala, 2016). SPSS version 24 was used for the data analysis for this research study.

The correlational design of this study warrants itself to an analysis of regression using a two-way ANOVA. ANOVA or analysis of variance is defined as "a statistical procedure used to measure interval or ratio scale data" (Privitera, 2015, p. 356). A two-way within subject analysis (Privitera, 2015, p. 357) is used in the analysis of the data. The number of ways determines the number of factors and within determines that the group all receives the same treatment (Privitera, 2015, p. 357).

Within the two-way analysis the focus is on two factors (independent variables) for each factor. Using this method of analysis, each research question is divided into a group of hypothesis and tests (James, 2018). For our study, these variants change depending on the question that is being analyzed in SPSS. Using SPSS, the tests were analyzed through a general linear model then univariate model.

Through this approach the ability to choose the dependent variable (the question) and the fixed factors (the independent variables) can be manipulated in the selection of these variables. The variables are displayed for the two-way ANOVA on question one. Through this process, a mean plot will be created. The use of a Tukey test will be used to compare the means from multiple groups in pairs. Tukey is only used for categorical data with more than two groups, such as year (Nie, L., 2018). Through SPSS, statistics were completed to show the tests of between-subjects' effects to show the regression output and to create significance for the test.

This shows not only the significance of factors, but also the significance of the interaction (Nie, 2018). The “Estimated marginal means” was used for the confidence interval to explain the variation of other groups.

The correlation and ability to answer each of the questions will be broken down by research question that was posed earlier in this section. The first question that will be defined for analysis is: How does participation in 4-H Fluid Power Experience increases career interest in STEM careers for participants? This question correlates to the Fluid Power Survey (2) section question 4 “How interested are you in a career in STEM”? (Figure 4.3,2) was used to answer this question. The five-point interval, Likert type scale was converted to a median and mode by assigning a value of one for strongly disagree and a value of five for strongly agree. The analysis for this item will be different than the remaining three questions because of using an ordinal type approach to this item. A chi squared analysis along with frequencies, median and mode will be used as well as univariate linear regression. A correlation was also created using gender and pre-post data. The following alternative hypothesis are generated based on this question.

H_a: Participation in the 4-H Fluid Power Challenge does impact career interest in STEM careers.

H_a: Male and female students have different level of career interest in STEM careers.

H_a: Sustained Participation in the 4-H Fluid Power Challenge does impact career interest in STEM careers.

Research question number two, “How does participation in the 4-H Fluid Power Experience improve attitudes about STEM?” correlates to the 4-H Common Measures survey science attitudes (Figure 4.2.3) were used to answer this question. A four-point interval Likert scaled was used for this section of answers. Strongly disagree to strongly agree were converted to numerical values with strongly disagree being 1 strongly disagree, 2 being disagree, 3 being agree, and 4 being strongly agree. A mean was created for the series of questions to use a two-way ANOVA.

H_a: Participation in the 4-H Fluid Power Challenge improves attitudes about STEM.

H_a: Male and female students differ in their attitudes toward STEM.

H_a: Where youth reside in the state of Indiana impacts their attitudes about STEM.

Research question number three is addressed with the Fluid Power Interest survey. The five questions are interval, Likert scale questions, and are used to answer the question “How does participation in the 4-H Fluid Power Experience influence positive attitudes about fluid power?" Each of the questions is on a five-point Likert scale with one being not at all and five being very much. Each of the values translate to value of one to five that then is averaged into a mean to conduct a two-way ANOVA.

H_a: Participation in the 4-H Fluid Power Challenge does impact positive attitudes about Fluid Power.

H_a: Male and female students have different level of interest in Fluid Power.

H_a: Sustained participation in fluid power have impacts the interest of youth who participate in the 4-H Fluid Power Challenge.

4.6 Validity and Reliability Measures

The survey instruments are validated through two different methods. Both instruments will be described in detail in this section, and issues of validity and reliability will be addressed. In their article "Validity and reliability of measurement instruments used in research" Kimberline and Winterstein (2008) state that "using tests or instruments that are valid and reliable to measure such constructs is a crucial component of research quality" (p.15). Addressing validity and reliability of the instruments lays a foundation of soundness to the study and the work around the study. "Validity is defined as the extent to which a concept is accurately measured in a quantitative study" (Heale, Twycross, 2015). The validity of concepts in this study will focus on interest, motivation and perceptions as related to STEM and fluid power.

The first instrumentation that was used is a pre-post survey that collects a baseline of perception and motivation data from participants. This data was collected in a pre-test survey administered before workshop day to all participants. The questions that were asked to assess the level of interest and understanding of the fluid power, the fluid power industry and careers in STEM fields. This gathers data not only on perceptions, but also on number of years participated, knowledge of fluid power prior to the workshop, and career interest (Figure 4.3.2). This survey uses open ended and interval scales. The interval scale data will be used in the comparison study (sub question 4, 6, and 7) along with gender (question 4).

Test validity is defined by Tuckman as "the extent to which the instrument measures what it purports to measure" (1999, p. 200). The validation for this instrumentation has been created through using a small a pilot year of data to look at common themes, and more importantly the content of the instrument that is being used. The pre-post instrument, which will be called “Fluid Power Survey”, was validated using content validity. This is defined as “the sample of situations or performances it measures is representative of the group from which the sample was drawn” (Tuckman, 1999).

Samples of the first year, pilot study, for the fluid power survey were taken and compared to the second year of data. Consistency of answers, which was seen using means, for each question, was seen between the two sets of data. This comparison established content validity for the instrument. The overall average for pre and post for each questioned stayed in the same consistency with a variance of plus/minus .1 for each question. This showed that the answers were answered consistently and not randomly, with the ability to show a relationship between answers on pre and post-test on a population of 67. Internal reliability of questions also was measured through conducting an r value on the series of questions.

Table 4-2 *Correlation of coefficient for 2016 participation set for the 4-H Fluid Power Survey pilot data.*

Correlation of Coefficient for 2016 Pre and Post Test 4-H Fluid Power Survey Pilot Data		
Question	**Records Analyzed**	**Correlation of Coefficient**
How interested are you in a career in science, technology, engineering and mathematics?	66	.864
I am interested in learning more about fluid power and how it works.	66	.761
I am interested in a career in fluid power or robotics.	66	.758

The validity of this survey was examined by University of California 4-H Program staff in 2015. In their paper Lewis et. Al (2015) detailed the validity testing that they did on the 4-H Common Measures Instruments. The use of construct validity conducted by the University of California 4-H Program was the basis for use of the 4-H Common Measures survey. For this study we only focused on the sections of the paper that are based on the 4-H Common Measures Science Grades 4-7 survey. The analysis consisted of:

Five steps were followed:

1. Ran an unconstrained EFA (Exploratory Factor Analysis) (i.e., did not specify how many subscales were expected).

2. Dropped any items that did not clearly belong on at least one subscale (i.e., items that had factor loadings lower than .30 on all factors).
3. Items that loaded onto a factor with only one other item were combined to make a new item that was the average of the two items to avoid problems with reliability of two-item subscales (cf. Widaman, Gibbs, & Geary, 1987).
4. Re-ran the EFA and repeated steps 2 and 3 as needed.
5. Final subscales were retained when a solution was found in which all remaining items worked well. (Lewis et. Al, 2015)

Through this analysis the following conclusions were drawn from their study. “Attitudes and Interested emerged as one factor. The two subscales were highly correlated (r=.72) and attitudes and interest show the same pattern of correlations” (Lewis et. Al, 2015). Using the recommendations and the validation from the study done by the University of California 4-H, this study used the 4-H Common Measures Science survey with focus on the the attitudes subscale. Based on the information retained and the analysis done through University of California, the use of the skills and application questions was not be used for this survey.

Table 4-3 *Analysis for 4-H Common Measures Grades 4-7 completed by the University of California 4-H Youth Development Program (Lewis et. Al, 2015).*

Reliability and Descriptive Statistics for the Two Science Measures

Subscale	Sample Size	Number of Items	Alpha	Mean (SD)	Range
Grades 4-7					
Attitudes	287	5	.84	3.00 (.58)	1.20, 4.00
Interest	291	4	.84	3.24 (.58)	1.00, 4.00
Average of all items	276	9	.90	3.10 (.54)	1.44, 4.00

4.7 Conclusion

In this chapter, the methodology for this study was laid out to create the framework of how the study is conducted. Youth participating in the 4-H NFPA Fluid Power challenge create the focus of participation and analysis for both parts of the study. The ability to analyze the data for this research study using a two-way ANOVA gives the opportunity to look at relationships between the independent and dependent variables as they relate to the study.

The use of a correlational study initiates a look at how the 4-H Fluid Power program delivery is related to variables such as gender and geographic location. The point of using this research design is not to influence the variables in the research, but instead of creating a correlation between the variables and other factors that are being assessed (Del Siegle, 2018). The relationship of the experience, gender and geographic location are the main factors that are being correlated in this study. The results of the data analysis will be discussed in Chapter five, along with results.

CHAPTER 5. RESULTS

5.1 Introduction

In this chapter, the results as they pertain to the three research questions and the hypothesis correlated with the question will be presented. Each question will include descriptive statistics, test of between-subject effects, graph of estimated marginal means and regression model. As was first explained in Chapter four, a two-way ANOVA using SPSS software to analyze the statistics was used. Even though, a variety of variables, questions, and options were present from the survey and questions collected, the focus for this study was on pre/post overall perception, gender, years participating, and residence. For this study, as defined in Chapter four, gender is defined at male and female. Years participating is defined as one, two, or three and represent the number of year that youth have participated in the 4-H Fluid Power Challenge. Residence is defined as rural (which is farm or non-farm with population under 10,000 persons), town (population 10,000-50,000 persons) or Urban (city or suburb with a population larger than 50,000 persons).

5.2 How does participation in the 4-H Fluid Power Experience increase interest in STEM careers for participants?

The first question that is proposed for this study is based on the 4-H Fluid Power Experience and the fluid power survey that consisted of nine questions related to STEM and the 4-H NFPA Fluid Power Challenge. The survey is designed as a pre/posttest in which youth take before the challenge and after the challenge. The survey is divided based on the research question being addressed. For research question number one, the survey question "How interested are you in a career in science, technology, engineering and mathematics?" was analyzed for this purpose. An ANOVA using this question as the dependent variable analyzed with multiple independent variables of gender and years participating as well as pre and post survey data.

The purpose of this research question is to look at how participation in the 4-H Fluid Power challenge effects youth perception of their interest in a career in STEM. For this purpose, two different hypothesis were analyzed based on the career survey question. One addresses the youth perception before and after the challenge based on their interest in STEM careers. The second hypothesis looks at gender as part of perception of interest in STEM careers before and after the fluid power challenge. The three-alternative hypothesis for each of the independent variables are below.

> H_a: Participation in the 4-H Fluid Power Challenge and does impact career interest in STEM careers.
>
> H_a: Male and female students have different level of career interest in STEM careers.
>
> H_a: Sustained Participation in the 4-H Fluid Power Challenge does impact career interest in STEM careers.

The descriptive statistics for this question are presented in Table 5.1 and Table 5.2. The results are broken down by year, as well as gender, and pre/post data. The data is presented with a pre and post mean for gender for each year. The data presents a mean, N, and standard deviation for each. The question is based on a 5-point Likert type scale. The scale uses not at all (1), not much (2), somewhat (3), pretty much (4), and very much (5). The five-point scales creates responses from 1-5, with the mean falling into that range for each of the categories.

For the first year, the mean from male participants on the pretest (n=16) was 4.25 and 3.80 (n=15) on the posttest with a standard deviation of .856 and 1.146 respectively. Female participants in their first year averaged a mean of 3.53 (n=17) with a standard deviation of 1.125 on the pretest and a mean of 3.00 (n=4) with a standard deviation of .816. Males in the second year reported a mean of 4.22 (n=9) with a standard deviation of .972 and 3.60 (n=5) with a standard deviation of 1.140 respectively on the pre and post-tests. Females in the second year reported a mean of 3.50 (n=4) with a standard deviation of .577 and 2.00 (n=3) with a standard deviation of 1.00. Males in the third year reported a mean of 4.50 (n=6) standard deviation of .837 and 4.33 (n=6) with a standard deviation of .866 respectively on the pre and posttests. Females in the third year reported a mean of 3.50 (n=4) with a standard deviation of 1.00 and 3.33(n=3) with a standard deviation of 1.155. A total of all pretest scores showed male scores had a mean of 4.29 (n=31) with a standard deviation of .864 and female scores had a mean of 3.52 (n=26) with a standard deviation of 1.005. The post-test for males was a mean of 3.88 (n=25) with a standard deviation of 1.071 and female responses with a mean of 2.80 (n=10) and standard deviation of 1.033. Total response mean was 3.95 (n=56) for pretest and 3.58 (n=36) for posttest with a standard deviation of .999 and 1.156 respectively. The results of the descriptive statistics for perception of career interest show a decline of the mean in perception of interest for all group and years participated. The third year of participation shows the least amount of difference in mean, but year is not an indicator of significance for this data set. Raw data for this information that is displayed in the following two table is located in Appendix C.

Table 5-1 D*escriptive statistics for "How interested are you in a career in science, technology, engineering and mathematics".*

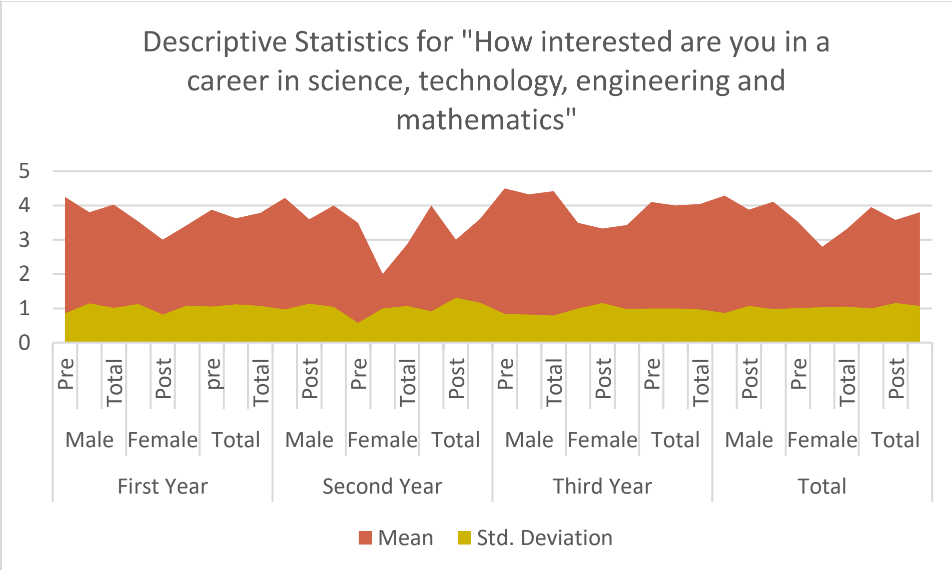
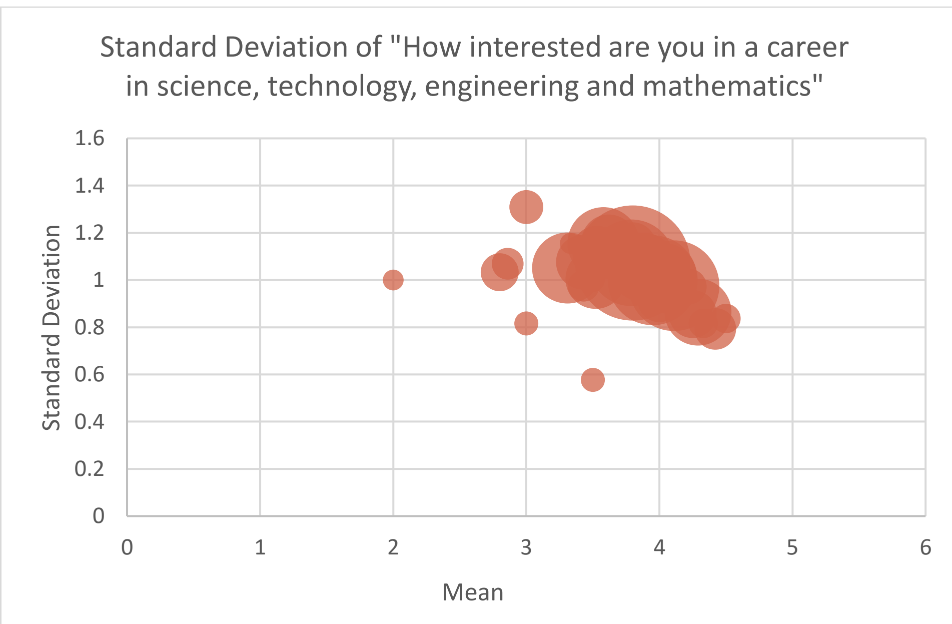


Table 5-2 *Standard Deviation of "How interested are you in a career in science, technology, engineering, and math?"*



The two-way ANOVA which looks at the relationships between the dependent and independent variable for each relationship is shown in Table 5-2. The test of the effects between subjects calculated the degrees of freedom (df), mean square, sum of squares, F value, and significance. The F value is found during the ANOVA (or regression test) that creates the value for significance for the variables that are being tested. For the question "How interested are you in a career in science, technology, engineering and mathematics" gender, years and pre/post were analyzed with the ANOVA for F value and significance. Table 5-3, 5-4, and 5-5 illustrate the findings from this section. Table 5-3 demonstrates the significance, 5-4 compares mean square and F value, while Table 5-5 shows all tests between subjects.

Gender indicated that the degrees of freedom was 1 with a 16.609 mean square and an F of 17.470 for a p value of .000. The value for significance that is being used for this test is .05. Anything below $p < .05$ is seen as significant for this test. Gender, for "how interested are you in a career in science, technology, engineering and mathematics", is at a significant value, as is the interaction between the question and gender are a significant relationship. Besides the tests on three hypotheses above, it was also tested whether there is a significant interaction between gender and participation. The result shows an F value of (17.40) with degrees of freedom (1) .The corresponding P-value is (.000), indicating that a significant interaction between gender and participation does exist. The significance of gender answers the second hypothesis on career interest and gender with supporting the alternative hypothesis. As stated in the alternative hypothesis, there is a difference in male and females in regard to career interest in STEM.

The second variable that was analyzed for "how interested are you in a career in science, technology, engineering, and math" was years. Years is defined as the number of years of participation for the respondent. Years had a degree of freedom of 2, mean square of 1.318, an F value of 1.386, and a $p=.255$. The significance that was set for this variable was $p < .05$. On a .05 level of significance the variable years in relationship with career interest in STEM is not significant for this study.

Table 5-3 *p values for gender, years, and participation for "How interested are you in a career in science technology engineering and mathematics?"*

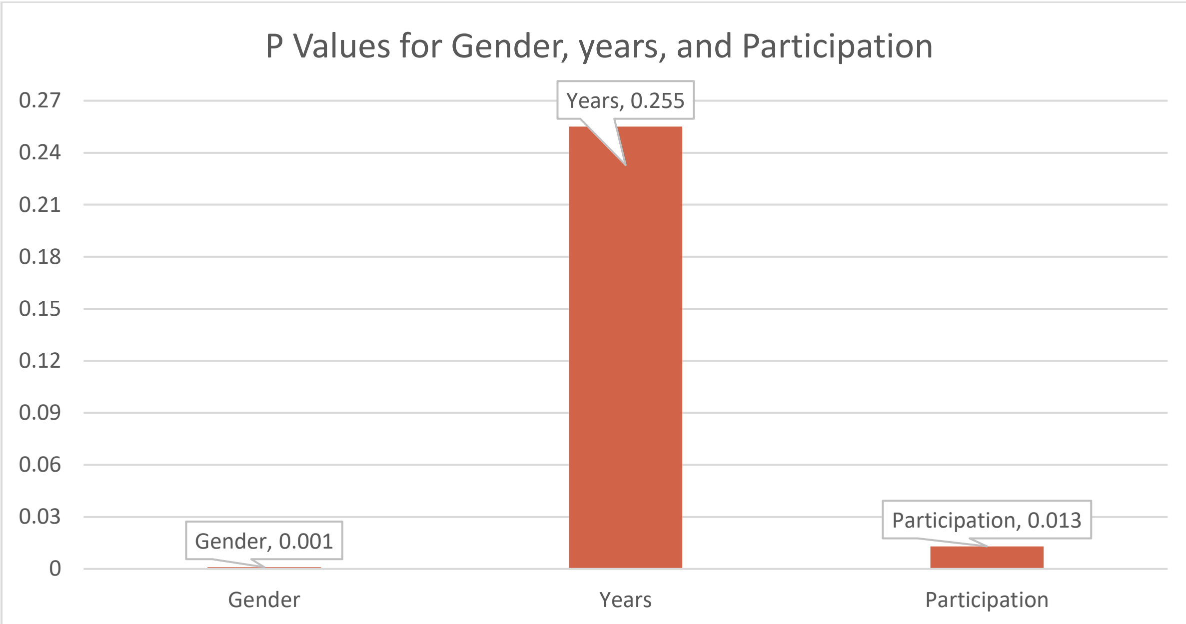
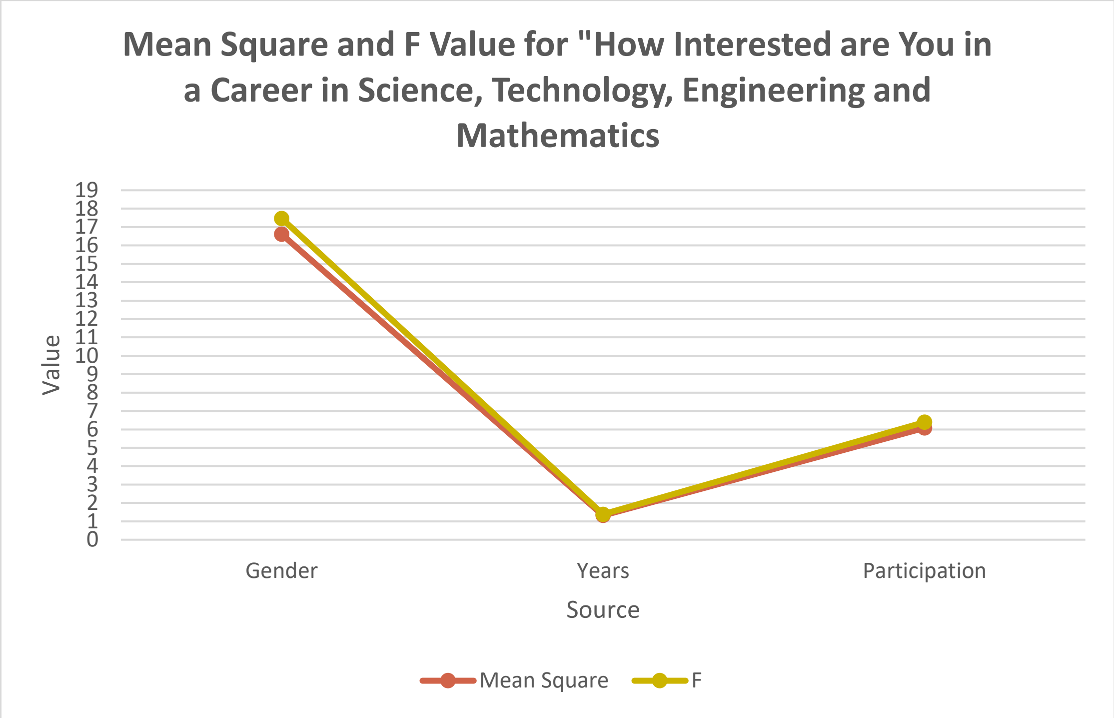


Table 5-4 *Test of effects between-subjects for "How interested are you in a career in science, technology, engineering, and math?"*

Tests of Between-Subjects Effects					
Dependent Variable: How interested are you in a career in science, technology, engineering and mathematics?					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	21.764[a]	4	5.441	5.723	.000
Intercept	907.343	1	907.343	954.361	.000
Gender	16.609	1	16.609	17.470	.000
Years	2.636	2	1.318	1.386	.255
Participation	6.072	1	6.072	6.387	.013
Error	82.714	87	.951		
Total	1436.000	92			
Corrected Total	104.478	91			
a. R Squared = .208 (Adjusted R Squared = .172)					

Table 5-5 *Mean Square and F Value for "How interested are you in a career in science, technology, engineering and mathematics".*



The third and final variable that was looked at for relationships with an F value test was participation responses before and after the program. The participation degree of freedom was 1, mean square of 6.072, F = 6.387 and a p=.013. Using the p< .05, participation with a p= .013, is seen as significant. The relationship between participation and career interest in STEM are significant for this study. The significance from this variable shows that there is a relationship between career interest and pre and post-test results. The relationship between the pre and post-test is significant, but the means for pretest and posttest totals declined. This means that the alternative hypothesis is proven because of the significance but needs to focus just on the relationship not on the increase of interest.

Figure 5.1 shows the residual plot of data based on observed, predicted and standard residual. The determination for standard regression for reading this plot is to determine if the design is "symmetric and no real pattern in design" (Statwing, n.d.). The univariate plot that is below fits the description that the plot is which meets the definition of the residual plot. The residual plot is determined by "observed-predicted" (Statwing, n.d.).

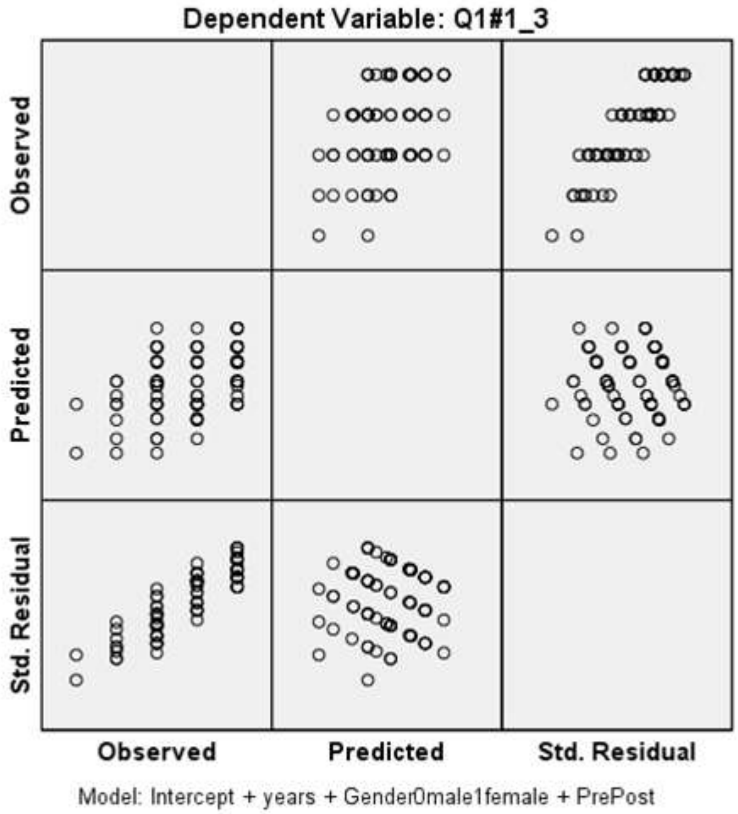


Figure 5-1 *Profile plot for "How interested are you in a career in science, technology, engineering, and math?"*

The final figures in this section that display the estimated marginal means of career interest are broken down into years one, two, and three (Figure 5-2, 5-3, and 5-4). The comparison model shows the decline of interest by representation of mean between pre and post based on gender. Each of the years of participation shows a similar decline and slope which further showcases the lack of significance year has in relationship to career interest. The slight decline for each year creates an understanding and representation of similar decline of perception of career interest between both males and females, but the average over the three years for post is 3.58, with male average post mean being 3.88 and female post mean being 2.80, is still above the median range of the Likert type scale which would be 3.0, with female post falling just below the median.

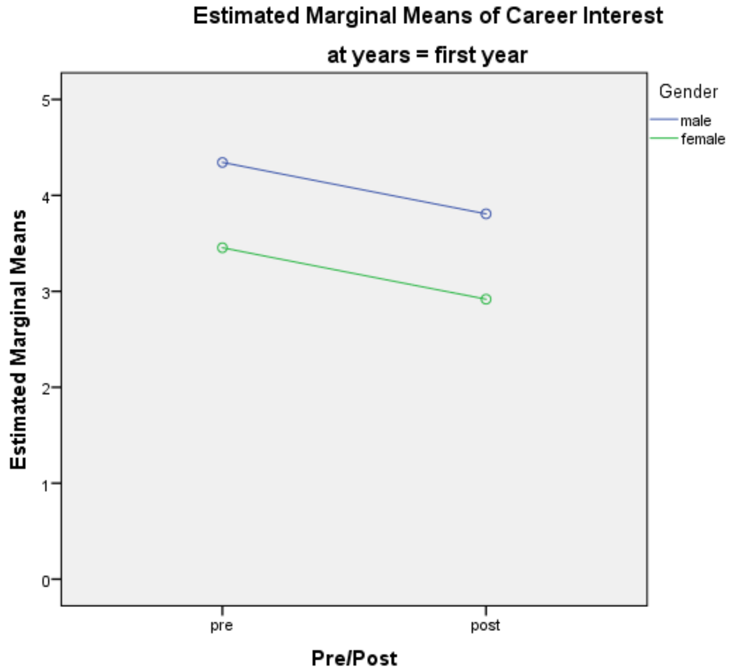


Figure 5-2 *Estimated marginal means of career interest broken down for year one for the question "How interested are you in a career in science, technology, engineering, and math?"*

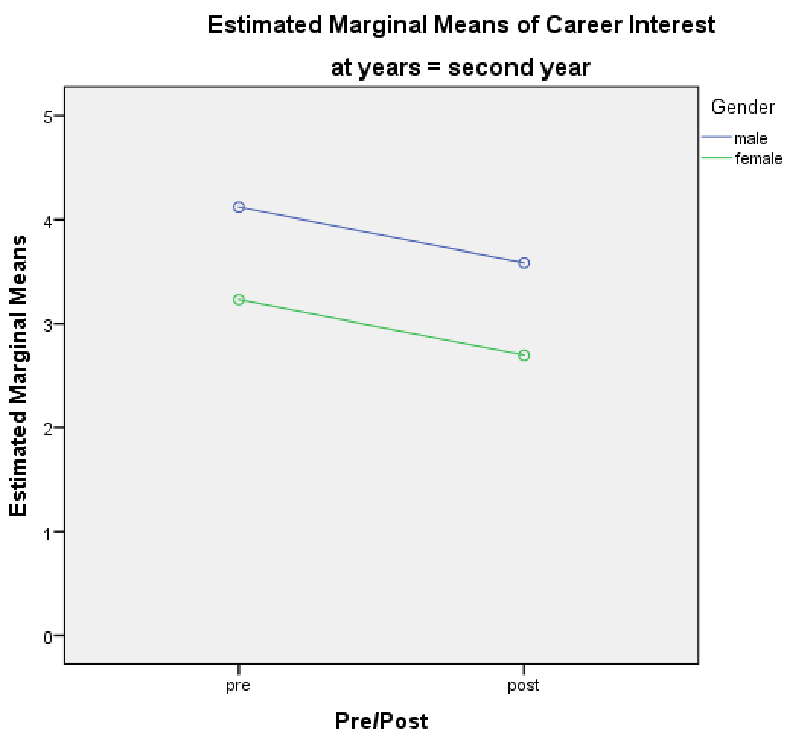


Figure 5-3 *Estimated marginal means of career interest broken down for year one for the question "How interested are you in a career in science, technology, engineering, and math?"*

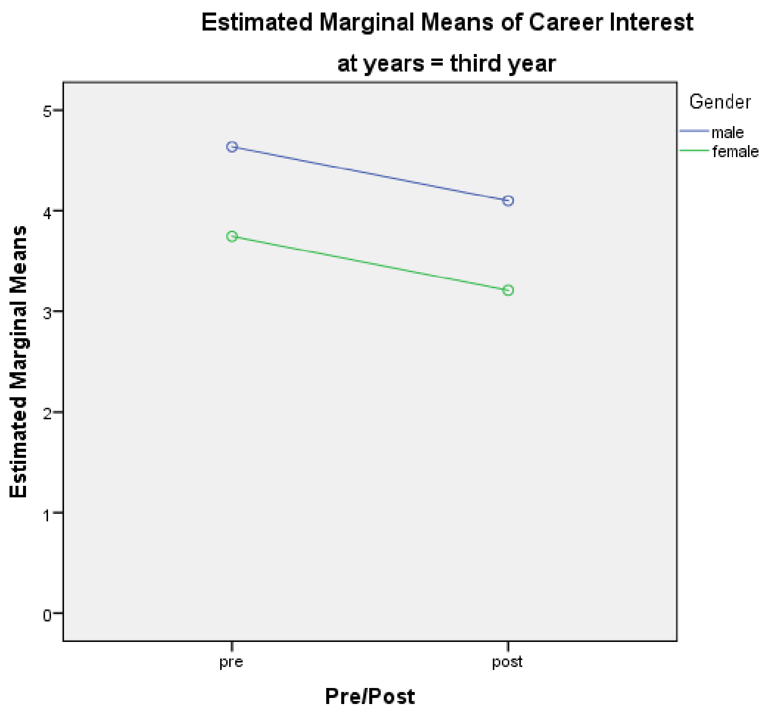


Figure 5-4 *Estimated marginal means of career interest broken down by years for the question "How interested are you in a career in science, technology, engineering, and math?"*

5.3 How does sustained participation in the Fluid Power Challenge improve attitudes about STEM?

The second research question in the study addresses attitudes about STEM and improvements to those attitudes through participation in the 4-H NFPA Fluid Power Challenge. The section consists of seven questions that address overall indicators of attitudes, interest, and engagement in STEM. The questions are on a four-point Likert scale from "strongly agree, agree, disagree, and strongly disagree." The mean of the seven questions was taken for each participant. The survey was posttest only. Table 5-6 and 5-7 showed analyzed data for the mean, standard deviation, and n-based gender and residence.

The median point for the Likert scale for the set of questions is 2.5. The mean for male respondents was 3.04 (n=31) with a standard deviation of .928. The mean for female respondents was 2.84 (n=14) with a standard deviation of .633. The mean for rural respondents was 3.13 (n=17) with a standard deviation of .556. The mean for town respondents was 3.09 (n=17) with a standard deviation of .897. The mean for urban respondents was 2.58 (n=11) with a standard deviation of 1.064. The overall mean for respondents was 2.98 (n=45) with a standard deviation of .845. All means are above the median of 2.5 for the survey questions. Most of the average means fall just above or just below the 3.0 (agree) mark of the scale. The raw data results for the test between subjects for P is displayed in Table 5-8.

Table 5-6 *Visual representation of the mean and standard deviation for data from interest, engagement, and attitude block of questions from the 4-H Common Measure Survey.*

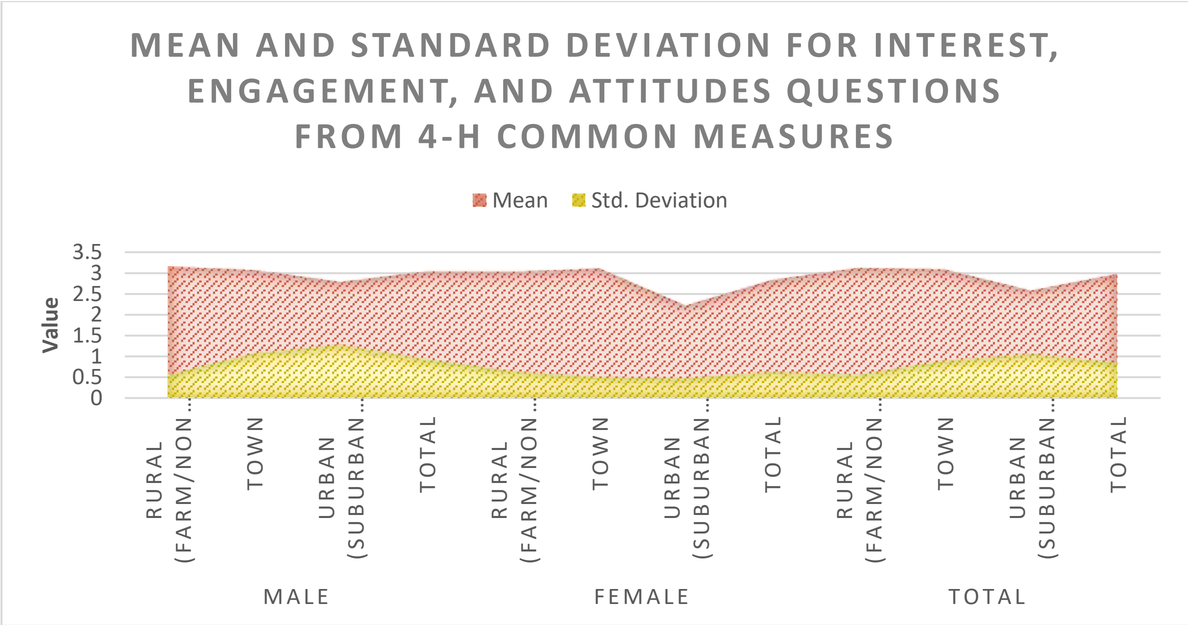
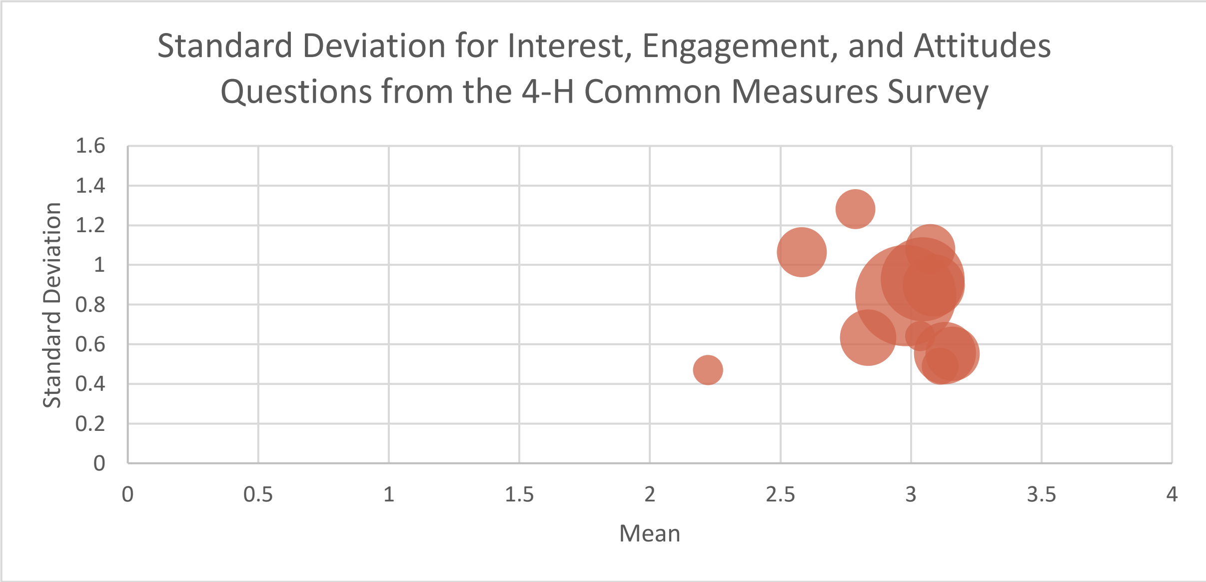


Table 5-7 *Standard deviation and mean intercept for interest, engagement, and attitudes questions from the 4-H Common Measures Survey.*



The first hypothesis for the second research question is:

H_a: Participation in the 4-H Fluid Power Challenge improves attitudes about STEM.

A two-way ANOVA was performed to determine the significance of the relationship between the respondents' perception and the set of questions on attitudes, interest, and engagement. The overall response to the STEM interest, engagement, and attitude questions was mean square of .872, degrees of freedom of 3, and F value of 1.240 with a p= .308. The p value set for these questions is p<.05. Using the .05 as a significance value, the .308 value determines that there is no significant relationship between overall perceptions and the interest, engagement, and attitudes. The determination based on this analysis is that the alternative hypothesis of participation in the 4-H Fluid Power Challenge improves attitudes about STEM is not accepted based on the relationship between the F test that was run for this set of data.

The second hypothesis attaining to the set of questions based on interest, engagement and attitudes is:

H_a: Male and female students differ in their attitudes toward STEM.

A two-way ANOVA was performed to determine the significance of the relationship between the respondents' gender and the mean of the set of questions on attitudes, interest, and engagement. The gender response to the STEM interest, engagement, and attitude questions was mean square of .294, degrees of freedom of 1, and F value of .418 with a p= .522. The p value set for this set of question is p<.05. Using the .05 as a significance value, the .522 value determines that there is no significant relationship between gender and the perception of interest, engagement, and attitudes. The determination based on this analysis is that the alternative hypothesis of student's gender differ in their attitudes about STEM is not accepted, based on the lack of significance of the F test performed above.

The third hypothesis attaining to the set of questions based on interest, engagement and attitudes is:

H_a: Youths' residence in the state of Indiana impacts their attitudes about STEM.

A two-way ANOVA was performed to determine the significance of the relationship between the respondents' residence and the mean of the set of questions on attitudes, interest, and engagement. The residence response to the STEM interest, engagement, and attitude questions was mean square of 1.097, degrees of freedom of 2, and F value of 1.559 with a p= .222. The p value set for this set of question is p< .05. Using the .05 as a significance value, the .222 value determines that there is no significant relationship between residence and the perception of interest, engagement, and attitudes. The determination based on this analysis is that the alternative hypothesis of youths' residence in the state of Indiana impacts their attitudes about STEM is not accepted based on lack of significance in the F test performed between the two items.

Table 5-8 *Test of between subjects for "interest, engagement and attitude questions" from 4-H Common Measures.*

Test of Between Subjects Effects					
Dependent Variable: Interest, attitudes, and engagement questions from Common Measures Questionnaire.					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.615[a]	3	.872	1.240	.308
Intercept	315.252	1	315.252	448.254	.000
Gender	.294	1	.294	.418	.522
Residence	2.193	2	1.097	1.559	.222
Error	28.835	41	.703		
Total	431.008	45			
Corrected Total	31.450	44			
R Squared = .083 (Adjusted R Squared = .016)					

Table 5-9 *Test between subject effects for independent variables gender and residence.*

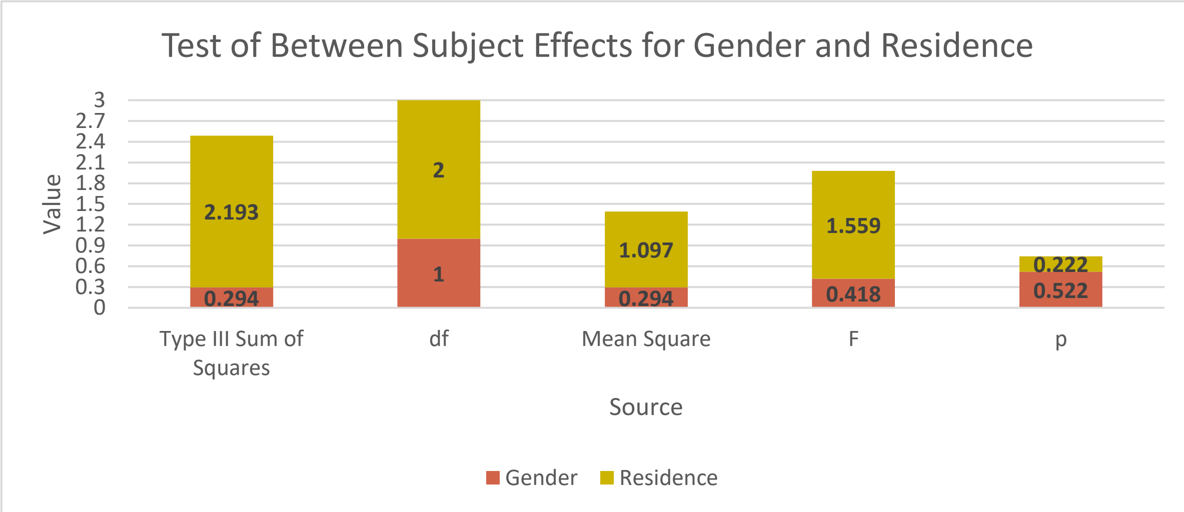


Figure 5.5 plots the standard residual which is the observed-predicted into a nine square plot that shows regression and symmetrical alliance within the plot. For each plot, a look of symmetrical and non-patterned show relevance in the regression. The plot shows some patterns in all areas except observed/standard residual. This further supports the lack of significance of the research that was presented in the section above. Figure 5.6 displays the estimated marginal mean based on gender and residence. The means show a similar slope decline, which further shows the lack of significance of residence or gender on the mean. The slope does show a difference in male and female mean, but only a slight difference, not within significance.

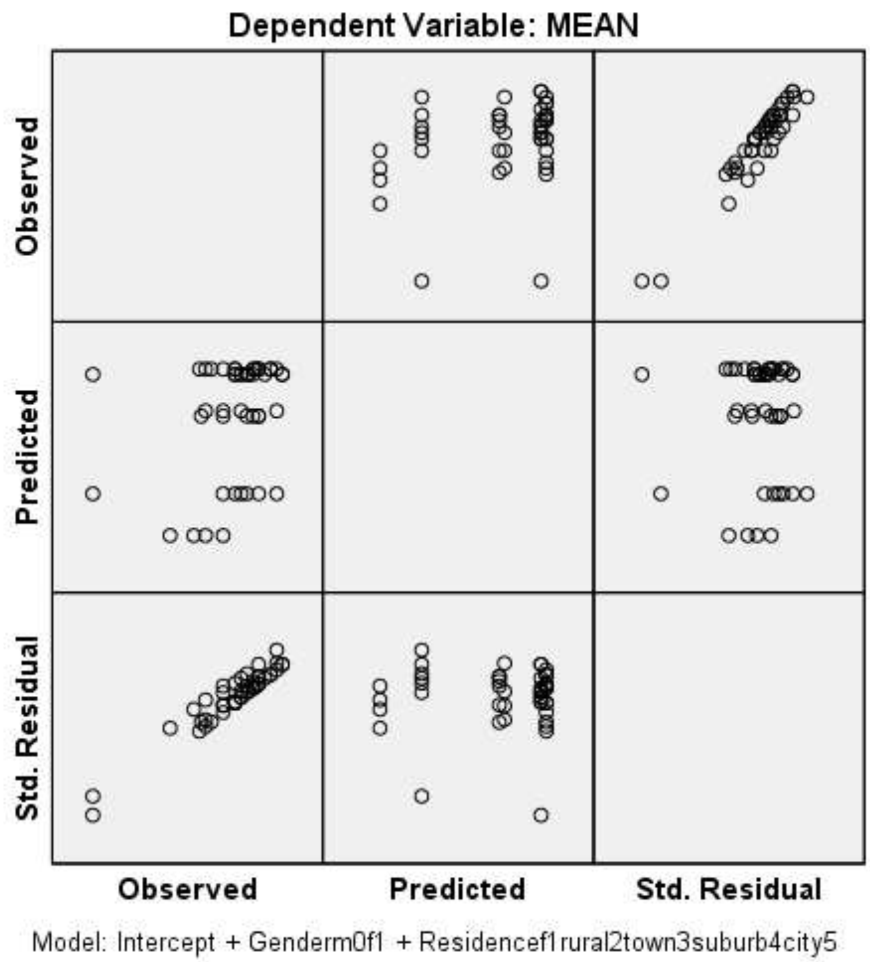


Figure 5-5 *Box Plot for "interest, engagement, and attitudes questions mean"*

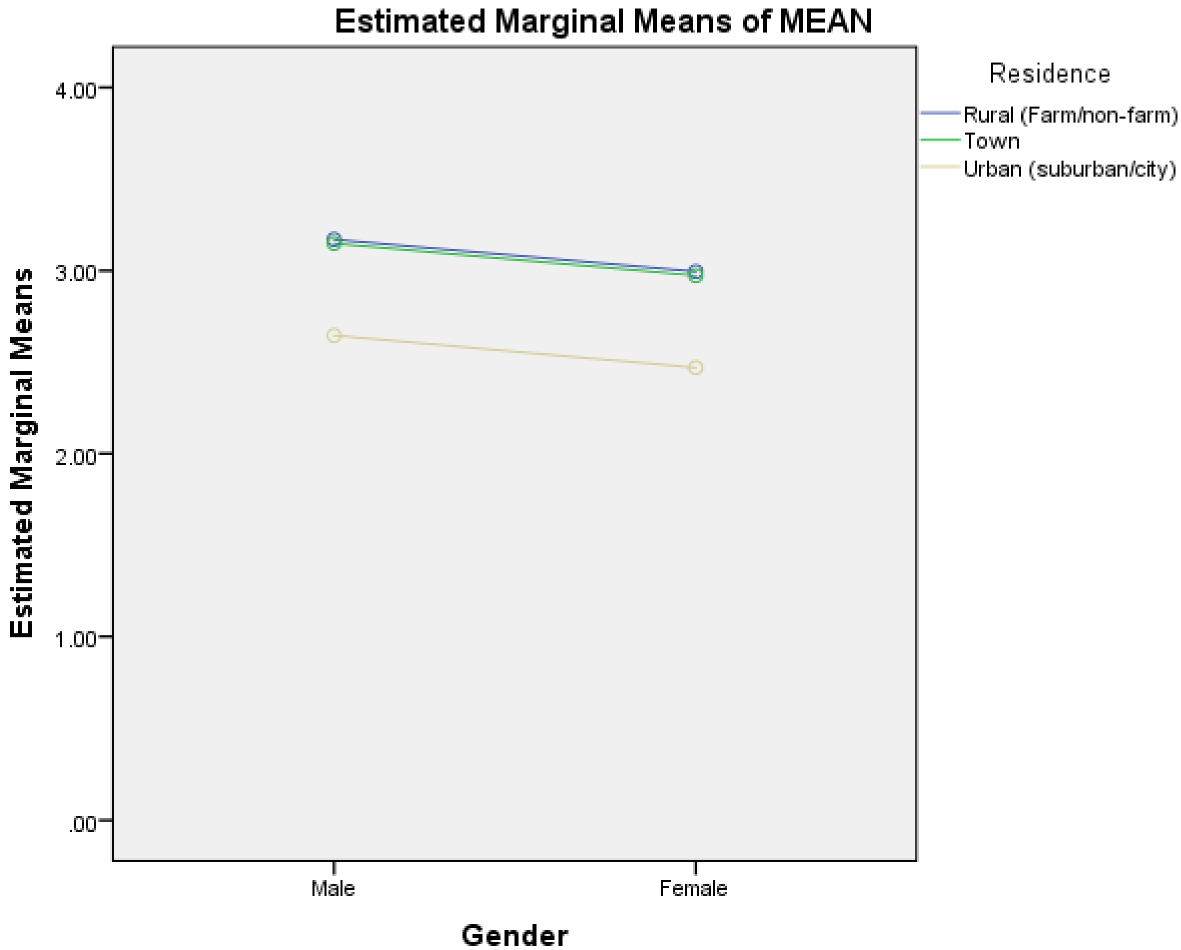
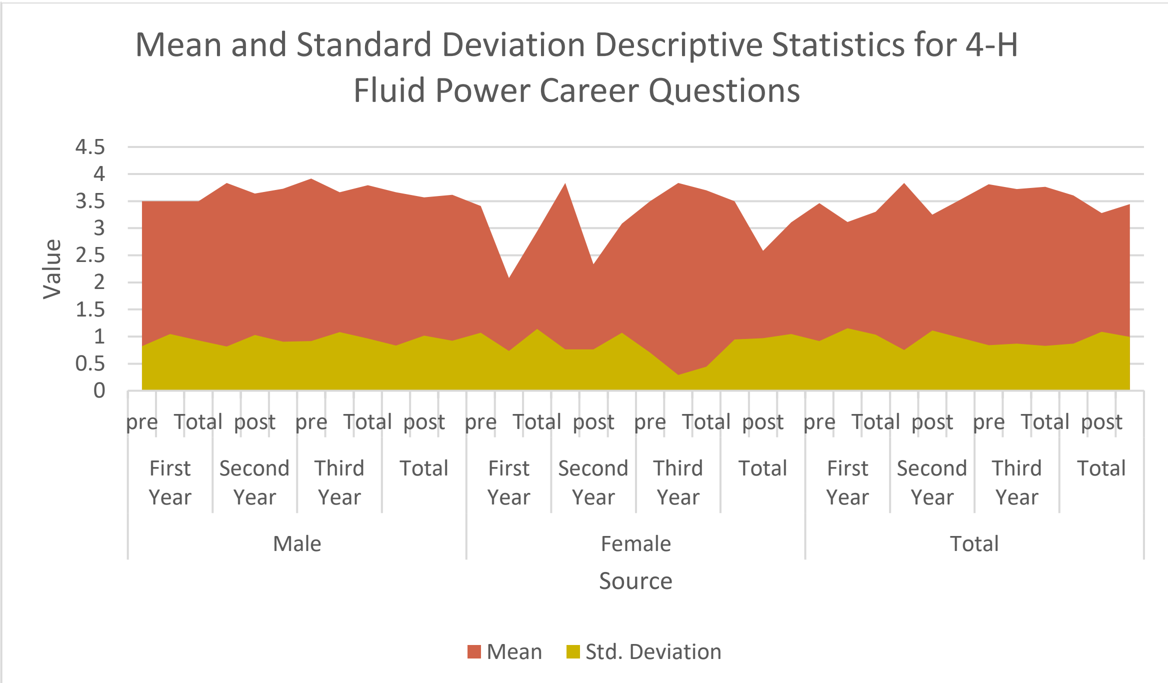


Figure 5-6 *Estimated marginal mean based on gender and residence.*

5.4 How does participation in the 4-H Fluid Power Experience influence attitudes about fluid power?

The third research question that was proposed for this study focuses on fluid power and attitudes about fluid power and fluid power careers based on participation in the 4-H Fluid Power Challenge. The analysis of this question is based on two questions on a 5-point Likert scale from not at all (1), not much (2), somewhat (3), pretty much (4), and very much (5). The median point for the scale is a 3. The two questions that were used for this analysis were "I am interested in learning more about fluid power and how it works" and "I am interested in a career in fluid

Table 5-10 *Mean and standard deviation descriptive statistics for the 4-H Fluid Power Career Questions*



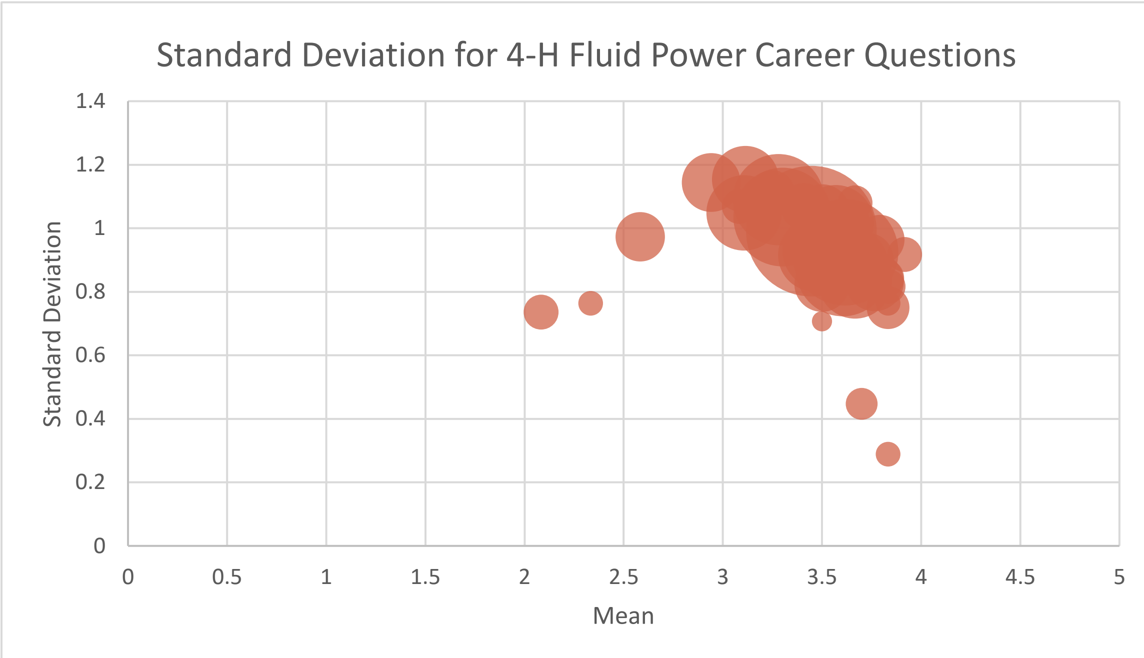
power or robotics". The mean of these two questions for each respondent were taken and used for the overall analysis for this response.

The descriptive statistics used for this question, as displayed in Table 5-10 and 5-11, were mean, standard deviation, and n by gender, year, and participation. Male respondents had a mean of 3.67 (n=27) for the pre-test with a standard deviation of .832 and 3.57 (n=29) with a standard deviation of 1.015 for post-test. Female respondents had a mean of 3.50 (n=16) with a standard deviation of .949 for the pre-test and 2.58 (n=12) with a standard deviation of .973 for post-test. First year participants reported a mean of 3.46 (n=26) with a .916 standard deviation on the pre-test and a mean of 3.11 (n=22) with a standard deviation of 1.154 on the post-test. Second year participants reported a mean of 3.83 (n=9) with a .750 standard deviation on the pre-test and a mean of 3.25 (n=10) with a standard deviation of 1.111 on the post-test. Third year participants reported a mean of 3.81 (n=8) with a .843 standard deviation on the pre-test and a mean of 3.72 (n=9) with a standard deviation of .870 on the post-test.

The first alternative hypothesis that is discussed for this chapter focuses on positive attitudes about fluid power. The alternative hypothesis read:

> H_a: Participation in the 4-H Fluid Power Challenge and does impact positive attitudes about Fluid Power.

Table 5-11 *Bubble plot of standard deviation for 4-H Fluid Power Career Questions.*



A two-way ANOVA was performed to determine the significance of the relationship between the respondents' perception before and after and the set of questions about fluid power interest and careers. The use of the between subjects' effects, seen in Table 5-12 and Table 5-13, were used to evaluate correlation between variables. The correct model response to the fluid power interest questions was mean square of 2.612, degrees of freedom of 4, and F value of 2.904 with a p value of p=.027. The p value set for this set of question is p<.05. Using the .05 as a significance value, the .027 for this model is significant.

The other statistics that is important to note in overall perception of fluid power interest is the participation data set. The participation data had a mean square of 3.141 with 1 degree of freedom and an F value of 3.492, resulting in a p value of p= .065. The .065 value is slightly higher than the p< .05 significance, but it is important to note the participation data is close to the significance level set for this study. The results from this section indicate that there is a correlation between the responses and the interest in fluid power. The mean shows a slight decline, but the mean is above the threshold of 3.0 which is the median for interest for this set of questions. For that reason, the alternative hypothesis of fluid power challenge impacts positive attitudes is accepted for this study.

The second alternative hypothesis that is discussed for this chapter focuses on positive attitudes about fluid power and the relationship of gender. The alternative hypothesis reads as:

H_a: Male and female students have different level of interest in Fluid Power.

A two-way ANOVA was performed to determine the significance of the relationship between gender and perception by using the set of questions about fluid power interest and careers. The use of the between subjects' effects, seen in the raw data Table 5-12, as well as in the chart in Table 5-13, was used to evaluate correlation between variables. The gender-based response to the fluid power interest questions was mean square of 5.061, degrees of freedom of 1, and F value of 5.627 with a p of p=.020. The p value set for this set of question is p<.05. Using the .05 as a significance value, the .020 for this model is significant. The significance establishes that there is a relationship between gender and fluid power interest. The mean average for female (3.11) and for male (3.62) a positive perception, even though for females in posttest the average was 2.6, which is slightly below the 3.0 median of interest in fluid power. The significance of this does lead to the acceptance of the alternative hypothesis that male and female students have a different level of interest in fluid power.

The third hypothesis for this research question is based on years of participation and the two fluid power questions. This question is regarding sustained participation and the increase in number of years of participation and the effect of interest in fluid power careers. The alternative hypothesis reads:

H_a: Sustained participation in fluid power have impacts the interest of youth who participate in the 4-H Fluid Power Challenge.

A two-way ANOVA was performed to determine the significance of the relationship between years of attendance and perception by using the set of questions about fluid power interest and careers. The use of the between subjects' effects, seen in Table 5-12 and Table 5-13, was used to evaluate correlation between variables. The years-based response to the fluid power interest questions was mean square of 2.805, degrees of freedom of 2, and F value of 1.559 with a p value of p= .217. The significance value set for this set of question is p<.05. Using the .05 as a significance value, the .2.17 for this model is insignificant. This establishes that there is not a significant relationship between the years of participation and the perception of interest in fluid power. This helps us determined that the alternative hypothesis stated for this subset question is not accepted.

Table 5-12 *Tests of between-subjects' effects for fluid power questions by gender, pre/post and years.*

Tests of Between-Subjects Effects					
Dependent Variable: Fluid Power career questions					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.450[a]	4	2.612	2.904	.027
Intercept	720.490	1	720.490	801.004	.000
Gender	5.061	1	5.061	5.627	.020
Years	2.805	2	1.403	1.559	.217
PrePost	3.141	1	3.141	3.492	.065
Error	71.059	79	.899		
Total	1079.250	84			
Corrected Total	81.509	83			
R Squared = .128 (Adjusted R Squared = .084)					

Table 5-13 *Visual depiction of ANOVA test between subjects for the 4-H Fluid Power career questions.*

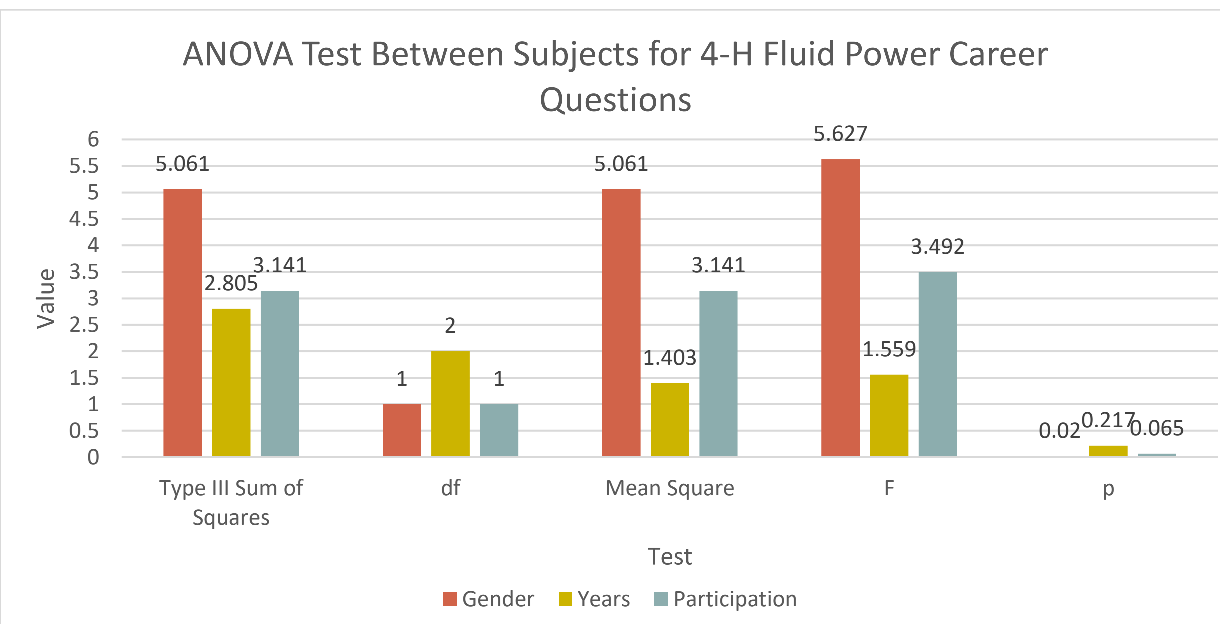


Figure 5-8 shows the residual plot of data based on observed, predicted and standard residual. Using the definition that was describe in section 5.2, this plot meets the requirements of symmetric and no distinct pattern of design. This determines the pattern of regression and randomness of the data. Figure 5-8, Figure 5-9, and Figure 5-10 displays the estimated marginal mean based on gender and year. The slope of the mean for each is similar. This similarity shows the understanding that years of participation is not a significant influencer on the data.

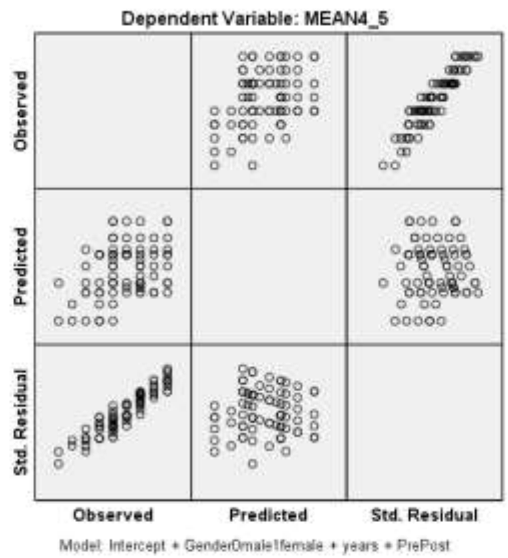


Figure 5-7 Profile plot for fluid power questions with gender, years and pre/post data.

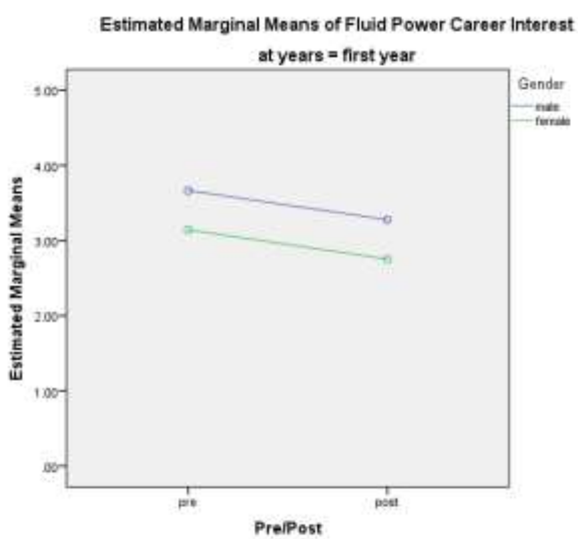


Figure 5-8 Estimated marginal mean for "fluid power career questions" based on gender and pre/post for first year.

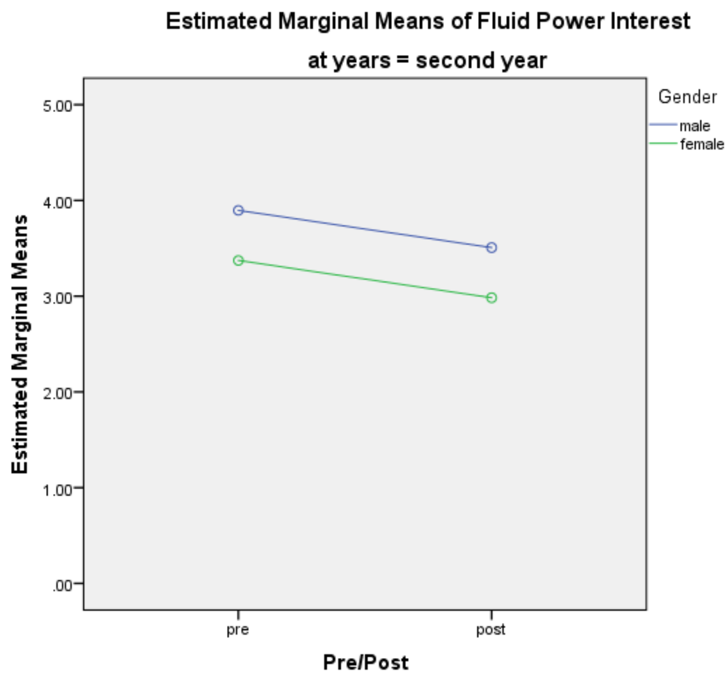


Figure 5-9 Estimated marginal mean for “fluid power career questions” based on gender and pre/post for second year.

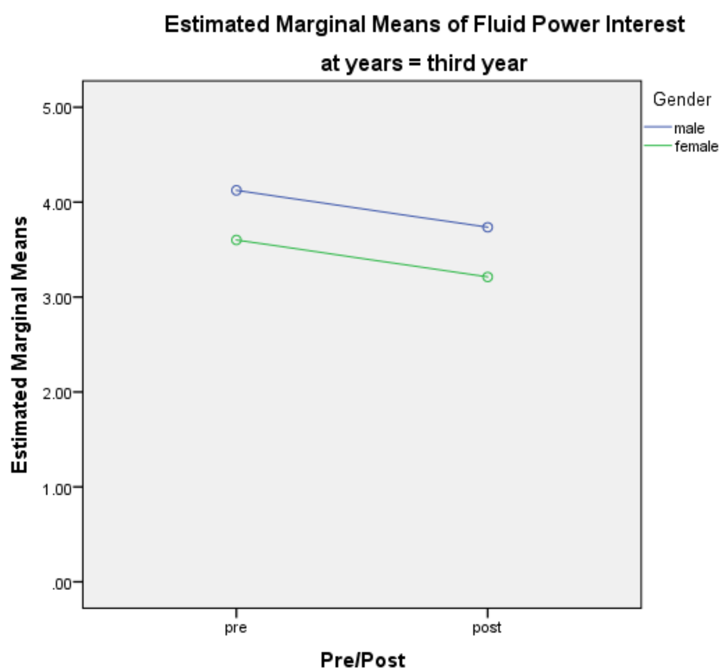


Figure 5-10 Estimated marginal mean for “fluid power career questions” based on gender and pre/post for third year.

5.5 Conclusion

The data presented in this chapter answers the three research questions that were first proposed in Chapter 1. The data that was presented concluded that there was a significance in correlation for Research Question 1 and Research Question 3, but not a significant response for Research Question 2.

CHAPTER 6. DISCUSSION, IMPLICATIONS FOR PRACTICE, AND FUTURE WORKS

6.1 Introduction

Chapter six will tie together Chapters one through five and expand on the implications of practice and further research. The chapter will start with a summary of the study, including purpose, research questions, and ties between research and results. The discussion section will elaborate on research and tie directly back to previous literature and studies with the results. This section will also bring out themes and contributions to the body of research in fluid power education. The section on limitations will discuss in depth the limitations of the study and generalizability of the study.

The section on implications of practice will look at what this study means for education and practices around fluid power education, especially in the non-formal setting. This section will also look at gaps in education and practice with regards to fluid power education. The recommendations for future research section will look at areas in which further research can be done within the fluid power education sector. This section will also look at the next steps for this study, and the adjacent research areas available to fluid power education. The final section in this chapter will wrap up the body of work with drawn conclusions from this chapter and the study.

6.2 Summary of Study

The purpose of this study is to evaluate the importance of sustained learning experiences in fluid power education. In order to create a complementary discussion section, the summary section of this dissertation, will be used to create a pathway for the discussion in section 6.3, as well as creating an overall summary and process presented in Chapters one through five. The primary focus is on the 4-H NFPA Fluid Power Challenge and how it creates an opportunity for youth in grades sixth through eight to increase interest, attitudes, and perception of science, technology, engineering, and mathematics (STEM) and fluid power through sustained, hands-on, youth driven learning experience. The study focuses on how opportunities in fluid power education meet the needs of middle school youth and increase interest in STEM.

Within this study three research questions were proposed to be answered through a quantitative research methodology. The research questions addressed the following areas:

1. Participation in the 4-H Fluid Power Challenge and its impact on interest in STEM careers.
2. Participation in the 4-H NFPA Fluid Power Challenge and its influence on attitudes about STEM
3. Participation in the 4-H NFPA Fluid Power Challenge and its influence on positive attitudes about fluid power.

Each of the three areas of focus (careers, STEM interest, and fluid power interest) created the focus for the study, the body of literature to support the study, and the methodology used to conduct the study. The scope of the study was on youth who participated in the 4-H NFPA Fluid power challenge and completed both of the survey instrumentation. The 4-H NFPA Fluid Power Challenge is eight weeks in length with instructional workshop at the beginning and a challenge/competition at the end. The process is self-guided/youth driven during the eight-week time youth are working on their competition prototype.

Literature for this study was focused in areas within 4-H and STEM that create an overall understanding of different areas in which the study focuses. The major areas of focus for the literature were on fluid power education, integrated STEM learning (project-based learning), 4-H learning models, sustained learning experiences through 4-H, and gender and geographic influences in STEM education. One clear theme throughout the research is the interrelated properties of each of the STEM disciplines, but also an unclear definition of what STEM learning looks like in a formal setting. Saito, et al (2016) describes this concept clearly in their article "A look at relationships (part 1): Supporting theories of STEM integrated learning environment in a classroom-a historical approach" (Saito, et al, 2016). In their article they state "an unclear definition of STEM education and the difficulty in establishing how STEM learning should appear in the classroom" along with limited research in integrated STEM learning causes the definition and assumptions in this field to be broad and diverse.

The vehicle for this study was the 4-H youth development program. The understanding of 4-H and how it operates, increases the understanding of this study. The use of two different surveys created a quantitative study that focused on the use of a two-way ANOVA to create understanding or correlational relationships between dependent and independent variables within the study. The independent variables that were looked at against different dependent contexts were gender, residence, years of participation and pre and post data.

6.3 Discussion

6.3.1.1 Introduction to Discussion

Throughout this study the underlying themes, as laid out in the summary of the study section above, lie in areas of 4-H, STEM integration and learning, and sustained experiences. The frame work discussed for this dissertation focuses on the three research questions and the results from each of those hypotheses that was analyzed in the results section. In this section, each of the research questions will be discussed in length based on results, relevant research, and practical application in the field of 4-H youth development and STEM education.

6.3.1.2 How does participation in the 4-H Fluid Power Challenge increase interest in STEM careers for participants?

Three alternative hypotheses were created in this section to answer the research question that was posed. The hypotheses were:

H_a: Participation in the 4-H Fluid Power Challenge and does impact career interest in STEM careers.

H_a: Male and female students have different level of career interest in STEM careers.

H_a: Sustained Participation in the 4-H Fluid Power Challenge does impact career interest in STEM careers.

As discussed in Chapter Five for this research question, a significant relationship was found between pre and post responses and the dependent variable question on the Fluid Power survey related to STEM careers, as well as a significant relationship with gender as well. Both topics of STEM career interest and gender and STEM career interest are heavily researched and identified as important areas of academic research in the past five years. One reason for this, as discussed by Dabney, Johnson, Sonnert, and Sadler, is “as STEM jobs increase, so does the concern that there are not enough qualified workers to fill the growing number of vacancies” (STEM Career Interest in Women and Informal Science, 2017). The increase concern of filling vacancies in industry, has helped to increase the need to facilitate research on STEM learning and career choice in academia, especially in the K-12 setting.

Research in STEM perception in relationship to STEM learning K-12 offers a vast dynamic of research and insight into a broad understanding of the effect and the need of programs in STEM for youth in K-12 setting. A variety of different issues are presented in research for why the barrier exists for youth and interest in STEM careers (Kier, M.W., Blanchard, M.R., Osborne, J.W., Albert, J.L, The development of STEM career interest survey (STEM-CIS), 2013, p. 462). Kier, et al (2013) indicate:

> Reports suggest reasons why students may hesitate to pursue STEM courses and careers, including a lack of quality preparation in mathematics and science in K-12 education systems, lack of access to money and technology, lack of guidance from adults who are knowledgeable of or affiliated with STEM careers, psychological barriers (such as believing mathematics and science are too difficult) and lack of role models in the field. (p. 462)

Kier, et al, indicate that even though there is a large amount of research on perception of STEM interest in both in-school and out-of-school areas, the specific interest of career exploration is lacking a verbose amount of research (2013). One result through their research was the development of the *STEM Career Interest Survey* which was developed to access career interest in middle school students (2013, p.463). Kier, et al (2013) determined through testing of 1000 middle school students in a rural setting that "they expect it will be beneficial to researchers, professional developers, and evaluators in measuring STEM career interest and the effects of STEM programs on changes in student interest in STEM subjects and careers". (p. 477).

One theme that is very apparent across recent research studies in career interest in STEM is this area of research is still in its infancy (Banning & Folkestad, 2012). The look at attitudinal interest of students was also done by Christensen, Knezek, and Tyler-Wood (2014, p.173). Their study focused on high school students enrolled in a pre-college STEM residential program at North Texas University (Christensen, et al., 2013, p. 174). The study found that students who participate in the program are more likely to have positive attitudes toward careers in STEM and have an interest in a STEM perception, than those of the normal high school average (Christensen, et al., 2013, p. 184). One theme that is consistent in the research into perception of career interest for students is "students need to be involved in hands-on STEM activities to make connection between education and future careers" (McCrea, 2010).

One apparent connection between the results that were discussed in Chapter five and the research on recent studies in career education is that the theme of hands-on, sustained research is important in the career interest area of STEM. Dabney, Tai, Almarode, Miller-Friedmann, Sonnert, Sadler, Hazari indicated in their study about STEM career interest of youth participating in out of school time (OST) activities that “students’ participation in OST activities was associated with a greater likelihood of indicating career interest in STEM while in university” (2012, p.75). This link creates an equal perception to what was discussed in the results section, showing the correlation between participation pre/post and career perception. STEM career interest for the 4-H Fluid Power challenge program had a mean average of 3.95 pre-test, or perception before participating in the fluid power challenge and 3.58 posttest, after the fluid power challenge. The median of the Likert type scale is 3.0. The F value that is used to provide significance in the relationship between pre and post data for the interest in career question was 6.387 with a significance of .013. The value creates an understanding of significance on a .05 scale.

The surprising portion of the correlation is also the negative slope of pre and post average relationships for this question. This result, one that wasn’t anticipated, showed the difference in perception of youth and their interest in careers before and after the challenge. This shows that perception is shifted through experience, and what was perceived as a high interest, was slightly lowered after precipitation, but still was above the median of the Likert scale. The other result that was interesting when looking at the mean values for participation, was that in the 3rd year the highest mean average was recorded, also the least amount of change between pre and posttest (4.10 pretest and 4.00 posttest). This supports the research identified earlier that the more experiences that youth participate in the more likely they are to continue an interest in a career in STEM.

The second hypothesis that was discussed for career interest was based on gender, using the same career question from the Fluid Power Survey. Gender and career interest is one area in which research has an overall interest. One reason for this interest is not only the amount of STEM career jobs that are forecasted to be open, but the lack of parity for females in STEM careers compared to their male counterparts. Research has shown that issues such as gender stereotypes (Walton & Spencer, 2009), culture cues (Bisland et al, 2011) and self-confidence and perception of ability (Dweck, 2006) are some barriers that exist in perception of interest of careers in STEM for females (Christensen & Knezek, 2017, p. 2).

"Understanding middle school students' perceptions regarding STEM dispositions is crucial to preparing our future STEM workforce as well as future citizens" (Christensen & Knezek, 2017, p. 10). The statement provided by Christensen and Knezek, articulates not only the results of this study in regard to gender, but also the impact for understanding gender and STEM interest. This study indicated a significant correlation between career interest and gender based on participation in the 4-H Fluid Power challenge. The correlation between career interest and gender is .000 which is a highly significant response. The interesting portion of this is the obvious difference in mean scores for females and male students participating in the fluid power challenge. Gender studies in STEM have found that females in high a decline of interest in STEM occurred compared to their male counterparts (Sadler, Sonnert, Hazari, Tai, 2012). In 2015 the Organization for Cooperation and Development reported that 20% of boys to only 5% of girls reported interest in STEM careers (Organization for Economic Cooperation and Development, 2015).

Dabney et al. (2012) also found in their study of college freshman that female participants that participate in an activity for two years or more, have more significant impact on their decision to pursue a career in STEM (p. 262). This correlates to the fact that the mean increases for those females that participate more than one year in the 4-H Fluid Power Challenge. This relationship found in our study is consistent with other studies that studied gender and career interest. The results of the study shows a similarity to the decrease amount of interest in careers for females to their male counterpart. Even though the pre/post relationship is negative, the story that it tells is that females lack confidence in their perception of interest in careers to their male counterparts in the program.

6.3.1.3 How does sustained participation in the Fluid Power Challenge improve attitudes about STEM?

The second research question focuses on attitudes about STEM and used a block of questions from the 4-H Common Measures survey. The research question focuses on attitudes about STEM based on relationships with over all participation, gender, and residence. The questions were around three alternative hypothesis which are listed below:

H_a: Participation in the 4-H Fluid Power Challenge improves attitudes about STEM.

H_a: Male and female students differ in their attitudes toward STEM.

H_a: Where youth reside in the state of Indiana impacts their attitudes about STEM.

The focus on this question for the 4-H Fluid Power Challenge served the purpose of looking at how the program influenced interest in STEM learning through an out of school time project-based learning environment. In this area, all three areas of focused were not significant in their relationship between the dependent variable of improvement of STEM attitudes and gender, participation, and residence. For this study, the importance of focusing on project-based learning is that it is a primary focus of 4-H programs with an experiential learning background.

The University of California 4-H program conducted a 2013 study on STEM programming using the Junk Drawer robotics curriculum that is part of the National 4-H curriculum series (Worker, Mahacek, 2013). The curriculum is set up to be used as a project-based learning opportunity, like the 4-H Fluid Power Challenge kits that are used. Worker and Mahacek found three concurrent themes within the curriculum during their study: “to learn” (guided science inquiry), “to do” (Engineering design), “to make” (technology creation) (2013, p. 19). Figure 6-1 shows a model that they adapted from the Massachusetts Department of Education to display this process that they created based on the study on the 4-H Junk Drawer Robotics curriculum (Workman, Mahacek, 2013).

The model uses the three areas to describe the process by which youth participate in the 4-H Junk Drawer Robotics curriculum. First “to learn” “emphasize(s) exploration and form the foundation which youth build conceptual understanding” (Workman, Mahacek, 2013, p. 19). Second “to do” is the actual design activity that uses the engineering design process, and third “to make” is the building and construction phase of the project. (Workman, Mahacek, 2013, p. 19). This process is the same process that is used in the 4-H NFPA Fluid Power Challenge. The connection between these two processes, show the consistency of the design process for project-based, experiential, and inquiry-based learning that is used to teach STEM in 4-H. This consistency creates a foundation and library of resources for Extension Educators to create STEM learning opportunities that are sustained to teach STEM skills and influence attitudes about STEM.

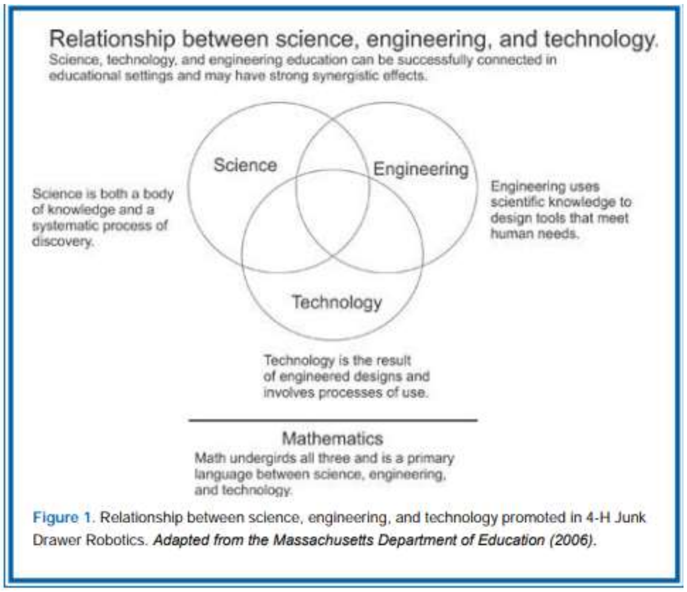


Figure 1. Relationship between science, engineering, and technology promoted in 4-H Junk Drawer Robotics. *Adapted from the Massachusetts Department of Education (2006).*

Figure 6-1 “Relationship between science, engineering, and technology promoted in 4-H Junk Drawer Robotics” (Workman, Mahacek, 2013, p. 19).

One of the interesting results, that is like other research that has been conducted is that on average males responded with a 3.04 mean on a 4.0 scale, and females responded with a 2.84 mean on a 4.0 scale. One note on this, is that the gap between the mean for males and females is less than the national average of interest in STEM. Research on the gender gap in STEM program participation is wide spread. One research study in the Journal of Chemistry, found three areas in which focus should be made for STEM experiences for females, hands-on experimentation, camp field trips, and female role models (Levine, Serio, Rardaram, Chaudhuri, & Talbert, 2015, p. 1641-1642). Researcher Claudine Schmuck refers to the gap, and more importantly the phenomenon of females choosing to not be interested in STEM as a “leaky pipeline” (Schmuck, 2017). Research conducted at the Los Alamos National Laboratory also concluded that it is necessary to use the identified challenges in STEM learning for females and create foundations to address those issues in the “pipeline” (Los Alamos National Laboratory & United States Department of Energy, Office of Technical Information, 2014).

Another interesting result, even though it did not rate as significant in the relationship, is that for residence, rural rated 3.13 on a 4.0 scale, while town rated 3.09 on a 4.0 scale, and urban rated 2.58 on a 4.0 scale. In a study on minimizing barriers to STEM programming conducted by Kentucky 4-H it was found that throughout the state of Kentucky most 4-H professionals are providing some type of STEM program (Noble, R.E., et al, 2018). The vast reach of cooperative extension programs and 4-H (as the youth outreach arm) increases the opportunities to provide STEM programming to audiences in all settings. Sallie and Peek suggest that access to mentors are a leading opportunity in why youth programs are successful (2014). 4-H, Indiana 4-H specifically, has a strong presence in rural communities, with active volunteers. It is understandable because of this presence in rural communities (and towns) that the average mean for rural would be 3.13 and town be 3.09. The foundation of the 4-H program started in rural communities, which would reflect this result.

6.3.1.4 How does participation in the 4-H Fluid Power Challenge influence attitudes about fluid power?

The third research question focuses primarily on attitudes about fluid power and career opportunities. This question uses the independent variables of years of participation, pre and post data (participation in general), and gender to look at fluid power attitudes. The alternative hypotheses that were answered for this section are:

H_a: Participation in the 4-H Fluid Power Challenge and does impact positive attitudes about Fluid Power.

H_a: Male and female students have different level of interest in Fluid Power.

H_a: Sustained participation in fluid power have impacts the interest of youth who participate in the 4-H Fluid Power Challenge.

This section of research looks directly at fluid power learning and careers using the Fluid Power survey and a Likert scale of 5. The median point for the Likert scale is 3.0. A use of a two-way ANOVA that produced an F value for this question revealed significance for gender and fluid power interest. The F value of 3.492 for pre and post data participation and significance of .065 is slight above the .05 threshold for significance in this research hypothesis. Similar to data on the other two research questions, a slight negative slope appears between the pre and post test data. This is believed to be about perception of interest and understanding prior to the challenge and after the challenge. The change is only slight and is not significant in the case for this set of data points.

"Today, educators, researchers, and business leaders say it is critical for engineers using fluid power to have easy access to training and development" (Hydraulics & Pneumatics, 2008).

This statement, as also iterated in the review of literature, is a base of the importance of experiential, project-based learning activities in fluid power education. With a limited amount of fluid power specific research, research in engineering education helps to show the trends and results of studies on focuses of mechanical engineering. One need that was addressed by this study, is to expose that research to specific K-12 research in fluid power design and interest, not just mechanical engineering design and research in the K-12 setting.

One main component that has been found in studies of STEM studies based on projects in engineering design is that "the consensus of industry, universities, and government is that STEM workforce crisis is due to shortage of domestic talent" (Morgan, Zhan, Leonard, 2013, p. 106). The NASA Hunch project, similar to the 4-H Fluid Power Challenge, focused on concepts of project management, project-based learning, creativity, "opportunities for students to determine if they are interested in pursuing STEM careers, and to develop an understanding of authentic engineering research and design" (Morgan, Zhan, Leonard, 2013, p.106). One aspect of the NASA Hunch project that also was seen as instrumental in the success of the project was the mentoring by college students for the high school participants (Morgan, Zhan, Leonard, 2013, p.106). This theme is consistent with feedback that has been given by coaches and participants antidotal for the 4-H Fluid Power Challenge.

As noted earlier in this section, correlation between gender and fluid power attitudes was found to be significant. Comparison between means for females and males show the following results. Pretest survey results for females noted a 3.5 mean and posttest of 2.58 with a change of -.92. Pretest survey results for males noted a 3.67 mean and posttest of 3.57 with a change of -.10. One interesting result when looking at the mean of answer for participants is that for participants who were in their third year of participation, the mean change was -.25 for male participants and +.33 for female participants in their third year. The third-year average (3.11) (of pre and post-test) for females is .76 (first year) and .62 (second year) higher. The post-test mean for third year (3.7) is 1.62 (first year) and 1.37 (second year) higher. The data for this suggests that continued participation for females in the Fluid Power Challenge increases their interest and perception of fluid power after the 2nd year, even more so than their male counter parts.

The perception of this, is very similar to research that has been conducted throughout engineering education and fluid power education. One theme that has been seen in research within engineering education and fluid power education is the importance of a holistic approach for female retention (Hitchcock, Hydraulics & Pneumatics, 2017). Cech et al (2011) looked at retention of females in engineering careers in their study, and found that “family planning, math self-assessment, and professional role confidence” as three themes that emerge into why females leave STEM fields (Cech, Rubineau, Sibey, & Seron, 2011, p. 656). Cech et al found that family plans and math self-assessment were early reasons that females dropped out of engineering programs at university (Cech, et al, 2011, p. 657). To bring this into further context for our study “STEM achievement disparities persist at the K-12 level, based on results from the Advanced Placement program as well as national and global exams” (Robelon, 2012). Another point from Wang & Degol is they found in their study of motivational pathways to STEM career choices, that females are motivated by communal needs such as serving other and making things better (Wang & Degol, 2013, 309). They also found that when STEM careers are put in a way that demonstrates the communal value to female students, they are more likely to choose to participate (Wang & Degol, 2013, 309).

6.3.1.5 Conclusion

In this study, we have found that three themes have emerged as primary discussion points that were discussed in this section. 1. The impact of gender on career choice and interest in fluid power careers. 2. STEM participation and learning interest based on participation in the fluid power challenge. 3. The importance of project-based, experiential learning programs in STEM for 4-H, especially in rural areas of Indiana.

It is through the understanding of these three themes that we continue to find the importance of creating sustained participation in STEM programs, specifically through 4-H, and finding the link between those sustained participation across STEM disciplines. Studies on rural robotics experiences found that the importance of life skill building for participants increased interest in further participation in STEM programs (Sage, Vandagriff, Schmidt, 2018). Throughout the entire set of research, the theme that emerges can be summed up by “making STEM fields more attractive to girls by promoting science as a human inquiry, involving the hands and the hearts as well as the brains, one’s personal interests and tastes—rather than an anonymous application of a universal method” (Froschl, Sprung, Archer, & Fancsali, 2003).

6.4 Implications for Practice

One of the most important parts of this research study, are the implications for practice for youth development practitioners or even more specifically 4-H Youth Development educators, specialist and administrators. The implications will be organized in a way to focus on implications in gender, residence, and STEM program in general. The implications will be built on research that was presented earlier in this chapter as well as other research that is presented in this section.

The first area for implications is the area of gender. As was discussed earlier in this chapter, gender is a significant area of focus for STEM programming regarding encouraging girls to participate in STEM and preparing females for STEM careers. One the implications that we can take from this research is that creating experiences for more than two years in STEM increases female attitudes, interest and career interest in FLUID power and STEM. Hughes et al, also raise the point that not only creating access for girls in STEM is important, but also make sure that create an identity in STEM (Hughes, Nzekwe, Molyneaux, 2013, p. 2000). Their study also indicates and reiterates the need for role models that look like the participants (Hughes, et al, 2013, p. 2001).

For 4-H audiences, this means creating opportunities in STEM where females have the opportunity to create an identity with the project, program or opportunity. The other important thought process is that when creating the programs that they are designed with audience in mind, and not just generalization. The second area that needs a focus is the recruitment of volunteers that represent the population that is being targeted. If females in STEM are the interest of the program, then female role models need to be sought out for parity. This does not just mean a female that is helping with the program, but females that are in the STEM field a serve as role models for the teams and programs.

The second area of implications to practice is residence. As seen in the results section, residence within this study was not a significant result, but it is important to mention in the implication section of the importance of residence in 4-H STEM program design, specifically in 4-H Fluid Power design. One of the most interesting results noted was the mean difference in rural and town verses urban. This poses the question, is how you design the program and present the program different based on residence. Overbey et al explain that in an urban setting issues beyond just learning STEM are present such as money, access, and lack of education of family members, especially in high risk urban areas (Overbey, Dotson, Meyers-Labadie, 2018).

A focus by 4-H programs on creating opportunities in an urban setting that meet the needs of that setting, increases the ability for the programs to be more successful. This also can be interpreted for rural and town settings as well. In urban settings creating environments that are easyly accessible for youth and provide mentors to help increase the sustainability create an opportunity for growth in STEM education and Fluid Power education through 4-H.

The last area of implications for this study is in areas of STEM education. Throughout the paper a theme of needs for STEM education in 4-H have been discussed. One of these needs that continues to rise to the top is creating indicators of quality for fluid power that align with STEM programs throughout the Indiana 4-H program. This creation of indicators of quality will help to enhance STEM programming opportunities and advances and give youth opportunities for growth through programs that are linked in STEM indicators. The ability to do this also contributes to the two plus years of participation for females increases the chance of sustainable interest in STEM. The creation of indicators of quality will also enhance the recruitment of volunteers and role models as a specific and measurable opportunity for contribution, as well as being able to measure program quality for 4-H STEM.

CHAPTER 7. CONCLUSION

7.1 Limitations

The limitation of this study on the 4-H NFPA Fluid Power Challenge can be grouped into three different distinct areas for discussion. The three areas are instrumentation, generalization, and indicators of quality. Each of these three areas created a limitation for the study and for the interpretation of the results for the study.

The first area of limitation is on instrumentation. One of the largest issues for this study is the lack of ability to link each participant's pre and post survey and their common measure survey together. Because of this limitation it was necessary to generalize the results by overall mean in the two-way ANOVA. The ability to link the participant surveys together, would have given the opportunity to run additional statistical analysis resulting in more specific conclusions based on each individual participant match. The second issue with survey design for this study is that youth chose the number of years that they participated in the program, and for the Fluid Power survey, it was noticed that the identification of this was up to interpretation whether one year was the first year or that they had participated one year prior to this year of participation. This interpretation could have caused skew of data. Creating a survey that has limited amount of interpretation needed for participants increases the ability of the survey to produce the most accurate results (Crosby III, Smith, 2018).

The second limitation for this study is the generalization of the results to populations. The ability to generalize the results is limited because of the size and the lack of set standards for the program implementation. Another issue with generalizability is with the 4-H Common Measures survey. One issue with the survey is that there is no pre-test evaluation of perception of attitudes for the event, and the instrument relies on the understanding of the student to rate the items based on the event participation. Lewis and Workman, in their article on the instrument, explain that the instrument decreases the ability to link to the specific event, because of the ambiguity of the questions (Lewis, Worker, 2015).

The third limitation for this study is the lack of indicators of quality for this program specifically, as well as for 4-H STEM in general. The National 4-H and Youth Outcomes and Indicators list is created by National 4-H Council and NIFA (2015) are created in conjunction with 4-H Common Measures. These indicators of quality are to access individual programs that they fit a standard indicator of quality for programs associated with a particular focus area, in this case STEM. One limitation for this study is that the program was developed through the NFPA and that the indicators of quality created for 4-H STEM do not fall perfectly in place, which makes it hard to generalize data from "all STEM programs" with the 4-H NFPA Fluid Power Challenge.

7.2 Recommendations for Future Research

Throughout this study, themes have emerged through the study of the 4-H NFPA Fluid Power Challenge. As the themes have emerged, there have been areas in which continued research would benefit the body of work and the development of fluid power education opportunities for youth participants. The areas for future research for this subject matter will continue to fall into sequence with the above-mentioned areas of gender, role model/coaches, and 4-H STEM.

The first recommendation for further research focuses on the coaches' role in the 4-H Fluid Power Challenge. Throughout the collection of data for this study, it became very clear that the role of the coach for different teams was different. The role of the coach (or mentor) has been identified through research as significant influence in STEM career decisions. It is that further research on the role of the coach including their background, interaction with the team, and years of participation, would add to the understanding of the role of the coach in the program as well as in influences within the 4-H Fluid Power Program.

Another recommendation for further research is into the design and setup of the eight weeks in between workshop and challenge day. This period is influential in the learning process, and further understanding the learning and design of this time, would be able to impact further understanding on how to design and create programming to enhance learning for teams and youth in fluid power education. One component of this research area not only is looking at the differences in design of time, but also how the design changes with number of years of participation. A comparative designed study with a control group and implementation group would be able to compare the differences in having a set learning process for the eight weeks verses a fluid learning process.

Another recommendation for further research in this area is a study on the program with control groups. Creating different program implementation styles and delivery modes for the program and testing across the teams would be able to look at the impact of program delivery modes and success. The area of program delivery modes can focus gender and residence as an ability to understand how learning differs for engineering design challenges based on gender and/or residence and delivery mode.

The final recommendation for research in the area of fluid power education and STEM is research in cross-program study between the effects of multiple 4-H STEM programs and their ability to work with each other to increase STEM learning for 4-H youth. The focus of gender and residence can be used to increase the understanding of how cross-program participation can influence STEM learning and career interest. The impact of years of participation and sustained learning in these areas would also be a part of creating a longitudinal study to increase STEM literacy, gender groups and geographical areas.

7.3 Conclusion

The study of the 4-H NFPA Fluid Power Challenge looked at the overall concepts of STEM learning based on residence, gender, and fluid power interest to determine how effective the program is for increases interest in these areas. Throughout this study it was found that gender and participation are significant indicators in learning for career interest and fluid power interest. The increased interest in this area, helps to understand the importance of programs in sustained learning for middle school youth in fluid power and STEM. The findings from this study focus on three areas.

The first is create a base of research in K-12 fluid power education that is needed within the research area. It also sets up future research to continue and to expand within the fluid power area. The basis of this research also helps to introduce concepts for research in this area beyond K-12. The second is to show a link between gender and STEM, and to open up the need for more specific research as well as practical implications for educators in this area. The third area is the need to develop more intricate program design to encompass 4-H STEM with inquiry and experiential learning as a basis. This area also opens up a need for more research in this area.

REFERENCES

Afriana, J., Permanasari, A., Fitriani, A., (2016). Project based learning integrated to STEM to enhance elementary school's students scientific literacy. *Jurnal Pendidikan IPA Indonesia, 5*(2), 261-267.

Amm, S. (2016). On the interplay of manufacturing engineering education ande-learning. *International Journal of Mechanical Engineering Education*, *44,*233-254.

Anonymous. (2008). No easy answers for industry education. *Hydraulics & Pneumatics, 61(4), 46-51*.

Bala, Jyoti. (2016). Contribution of SPSS in Social Sciences Research. *International Journal of Advanced Research in Computer Science, 7*(6), 250-255.

Ball, Christopher. (2017). Pressurizing the STEM Pipeline: An Expectancy-Value Theory Analysis of Youths' STEM Attitudes. *Journal of Science Education & Technology,26*(4), 372-383.

Bandura, A. (1977). *Social learning theory*. Englewood Cliffs New Jersey: Prentice-Hall.

Banning, J., & Folkestad, J.E., (2012). STEM education related dissertation abstracts: A bounded qualitative meta-study. *Journal of Science Education and Technology, 21(6), 730-741)*.

Barker, B., Grandgenett, N., & Nugent, G. (2009). A new model of 4-H volunteer development in science, engineering, and technology programs. *Journal of Extension*, *47*, 1-6.

Barker, B., Larson, K., & Krehbiel, M. (2014). Bridging formal and informal learning environments. *Journal of Extension*, *52*, 1-8.

Bisland, M., Kekelis, L., McCreedy, D., Koster, E., Gupta, P., and Roman, C. (2011). *Science Museum Roundtable*. Discussion at the NCWIT K-12 Alliance Summit, New York.

Blessinger, P., & Cafora, J. (2014). Innovative Approaches in Teaching and Learning: An Introduction to Inquiry-Based Learning for Faculty and Institutional Development. *Innovation in Higher Education and Learning*, *1*, 3-34.

Bodner, G., & Orgill, M. (2007). *Theoretical frameworks for research in chemistry/science education*. Upper Saddle River, NJ: Pearson Prentice Hall.

Boone, Harry N., Jr., & Boone, Deborah A. (2012). Analyzing Likert Data. *Journal of Extension, 50*(2), 1-5.

Bourdeau, V. (2004). 4-H experimental education-A model for 4-H science as inquiry. *Journal of Extension*, *42*, 1-6.

Buffington, P. (2017, May 3). Closing STEM Education Opportunity Gaps for Rural Students. Retrieved September 15, 2018, from http://ltd.edc.org/closing-STEM-education-opportunity-gaps-rural

Capraro, R., & Slough, S. (2013). The development and evaluation of experiential learning workshops for volunteers.

Cech, E., Rubineau, B., Silbey, S., & Seron, C., (2011). Professional role confidence and gendered persistence in engineering. *American Sociological Review, 76(5), 641-666.*

Center for Innovation in Research and Teaching. Quantitative Approaches. Retrieved April 13, 2018, from http://cirt.gcu.edu/research/developmentresources/research_ready/quantresearch/approaches

Christensen, Kenzek, & Tyler-Wood. (2014). Student perception of science, technology, engineering and mathematics (STEM) content and careers. *Computers in Human Behavior, 34(C), 173-186.*

Christensen, R. & Knezek, G. (2017). Relationship of middle school student STEM interest to career intent. *Journal of Education in Science, Environment and Health (JESEH), 3(1), 1-13.*

Choney, S. (2017, March 01). Microsoft study in Europe reveals when and why girls' interest in STEM fields begins to wane - The Fire Hose. Retrieved September 14, 2018, from https://blogs.microsoft.com/firehose/2017/03/01/microsoft-study-in-europe-reveals-when-and-why-girls-interest-in-stem-fields-begins-to-wane/

Chyung, S., Roberts, K., Swanson, I., & Hankinson, A. (2017). Evidence-Based Survey Design: The Use of a Midpoint on the Likert Scale. *Performance Improvement*, *56*(10), 15-23.

Committee on the Future of the Colleges of Agriculture in the Land Grant University System, (1995). College of agriculture at land grant universities: A profile. National Academy Press, Washington, D.C.

Creswell, J. (2014). *Research design: Qualitative, quantitative and mixed methods approaches*. LOs Angeles, CA: Sage Publishing.

Crosby, R., & Smith, E. (2018). Creating a new survey for specific population: The kids' church survey. *SAGE Research Methods Cases*. Doi:10.4135/9781526447333.

Dabney, K., Johnson, T., Sonnert, G., & Sadler, P. (2017). STEM career interest in women and informal science. *Journal of Women and Minorities in Science and Engineering*, 23(3), 249-270.

Dabney, K., Tai, R.H., Almarode, J.T., Miller-Friedmann, J.L, Sonnert, G., Sadler, P.M., Hazari, Z., (2012). Out-of-school time science activities and their association with career interest in STEM, International Journal of Science Education, Part B, 2:1, 63-79, DOI: 10.1080/21548455.2011.629455.

Del Siegle, (2018). Introduction to correlation research. *Educational Research Basics*. University of Connecticut.

Dillivan, K., & Dillivan, M. (2014). Student interest in STEM disciplines: Results from a summer day camp. *Journal of Extension*, *52,* 1-21.

Duncan, Stenbeck. (1987). Are Likert scales unidimensional? *Social Science Research, 16*(3), 245-259.

Dweck, C. (2006). Is math a gift? Beliefs that put females at risk. In *Why Aren't More Women in Science? Top Researcher Debate the Evidence*, ed. S.J. Ceci and W.M. Williams, 47-55. Washington, DC: American Psychological Association.

Enfield, R., Schmitt-McQuitty, L., & Smith, M. (2007). The development and evaluation of experiential learning workshops for volunteers. *Journal of Extension*, *45*, 1-5.

Engineering Design Process Models. (nd). Retrieved from https://www.linkengineering.org/Explore/EngineeringDesign/5824.aspx

English, L.D., King, D., Smeed, J., (2017). Advancing integrated STEM learning through engineering design: Sixth-grade students' design and construction of earthquake resistant buildings, *The Journal of Educational Research*, *110:3, 255-271*, DOI: 10.1080/00220671.2016.1264053

Experimental learning: Fact sheet. (2011). Retrieved 2017-2-7, from www.4-H.org/resource-library/

Fayer, S., Lacey, A., Watson, A. (2017). STEM occupations: Past, present, and future. *Spotlight on Statistics*. Bureau of Labor Statistics.

Field, A. P. (2005). *Discovering statistics using SPSS: (and sex, drugs and rock n roll)*. London: Sage Publications.

Fluid power education: What went wrong. (1994).

Froschl, M., Sprung, B., Archer, E., & Fancali, C. (2003). *Science, gender and afterschool: A research-action agenda*. National Science Foundation. http://www.edequity.org/sgaagenda.pdf.

Gifi, C., McNelly, J., Dollar, B., Carrick, G., Drew, M., Gangula, B., (2016). The skills gap in Manufacturing, 2015 and beyond. Deloitte Development LLC. United Kingdom.

Gonzalez, H., Kuenzi, J., (2012). *Science, technology, engineering, and mathematics (STEM) education: A primer*. Congressional Research Service.

Heale, R., & Twycross, A. (2015). Validity and reliability in quantitative studies. *Evidence-based nursing*, ebnurs-2015.

Hill, P., Peterson, G., & Francis, D. (2015). 4-H and the maker movement. *Journal of Extension*, *53*, 1-4.

Hitchcox, A. (2017). Does fluid power have a gender issue? *Hydraulics & Pneumatics.* Retrieved from https://www.hydraulicspneumatics.com/blog/does-fluid-power-have-gender-issue.

Honey, M., Pearson, G., & Schweingruber, H. (2014). *Stem integration in k-12 education: Status, prospects, and an agenda for research*. Washington D.C.: The National Academic Press.

Hoerr, T. R. (2002, Feb). Learning styles. *Scholastic Parent & Child, 9,* 42-47. Retrieved from https://search-proquestcom.ezproxy.lib.purdue.edu/docview/210651583?accountid=13360

Hughes, R.M., Nzekwe, B., & Molyneaux, K.J. (2013). The single sex debate for girls in science: A comparison between two informal science programs on middle school students' STEM identity formation. *Research in Science Education, 43(5), 1979-2007).*

Indiana 4-H Website. (2016). Retrieved 2-7-2017, from wwww.extension.purdue.edu/4H

Israel, S. (2017, November 1). Building America's Future: STEM Education Intervention is a Win-Win. Retrieved September 15, 2018, from https://publicpolicy.wharton.upenn.edu/live/news/2188-building-americas-future-stem-education/for-students/blog/news.php

James, (2018). Stats: Two-way ANOVA. Richland University Department of Statistics. Retreived on September 19, 2018 from https://people.richland.edu/james/ lecture/m170/ch13-2wy.html

Katehi, L., Pearson, G., Feder, M., Board, O.S.E.S, Division, O.B.A.S.S., & Teacher, A.C.S. (2009). Engineering in k-12 education: Understanding the status and improving the prospects. Retrieved from https://ebookcentral.proquest.com

Kier, M.W., Blanchard, M. R., Osborne, J.W., & Albert, J.L. (2014). The development off the STEM career interest survey (STEM-CIS). *Research in Science Education, 44(3), 461-481*.

Kimberlin, C., Winterstein, A.G, (2008). Validity and reliability of measurement instruments used in research. *American Journal of Health-System Pharmacy*. (23) 2276-2284; DOI: https://doi.org/10.2146/ajhp070364

Kinsey, Sharon, & Calvert, Matthew. (2013). *Using multiple youth programming delivery modes to drive the development of social capital in 4-H participants.* New Directions for Youth Development,138, Wiley Periodicals, Inc. Published online: wileyonlinelibrary.com, DOI: 10.1002/yd.20058

Kolb, D., Boyatzis, R., & Mainemelis, C. (1999). *Experiential learning theory: Previous research and new direction*. New Jersey: Lawrence Erlbaum.

Kuenzi, J. (2008). Science, technology, engineering, and mathematics education: Background, federal policy, and legislative action. *Congressional Research Service Report , 35* , 1-48.

Lappe, J. (2000). Taking the mystery out of research: Descriptive correlational design. *Orthopaedic Nursing*, *19*(2), 81.

Levine, M., Serio, N., Radaram, B., Chaudhuri, S., & Talbert, W. (2015). Addressing the STEM Gender Gap by Designing and Implementing an Educational Outreach Chemistry Camp for Middle School Girls. *Journal of Chemical Education, 92(10), 1639-1644.*

Lewis, K. M., Horrillo, S. J., Widaman, K., Worker, S. M., & Trzesniewski, K. (2015). National 4-H Common Measures: Initial Evaluation from California 4-H. *Journal of Extension,53*(2), 1-5. Retrieved April 10, 2018, from https://www.joe.org/joe/2015april/rb3.php/www.joe.org/joe/2015april/rb3.php

Lewis K. M., & Worker, S.M., (2015). Examination of Attitude and Interest Measures for 4-H Science Evaluation. *Journal of Extension, 53(3).*

Los Alamos National Laboratory & United States, Department off Energy, Office of Scientific Technical Information. (2014). *Women in STEM: Barriers, milestones, challenges, and solutions.* Los Alamos, N.M.: Oak Ridge, Tennessee: Los Alamos National Laboratory; distributed by the Office of Scientific and Technical Information, U.S. Department of Energy.

Marulcu, Ismail, & Barnett, Michael. (2016). Impact of an Engineering Design-Based Curriculum Compared to an Inquiry-Based Curriculum on Fifth Graders' Content Learning of Simple Machines. *Research in Science & Technological Education, 34*(1), 85-104.

McCrea, B. (2010). Engaging girls in STEM. The Journal. Retrieved from: http://thejournal.com/articles/2010/09/08/engaging-girls-in-stem.aspx.

MFG Infographic Final. (2017). Infographic on National Manufacturing Day.

Morgan, J., Zhan, W., & Leonard, M., (2013). K-12 project management education: NASA hunch projects. *American Journal of Engineering Education, 4(2), 105-118*.

Moser, Stephanie. (2018). Exploring the development and impact of learning styles: An empirical investigation based on explicit and implicit measures. *Computers & Education,125,* 146-158.

Myers, A., & Berkowicz, J. (2015). *The STEM shift: A guide for school leaders*. Corwin, a Sage Company, Thousand Oaks, California.

National 4-H Learning Working Group (2016). The 4-H learning experience: A framework for learning and teaching in 4-H. Retrieved April 20, 2018 from https://nifa.usda.gov/sites/default/files/asset/document/The%204-H%20Learning%20Experience.pdf

National Fluid Power Association (2018). Member Survey Results Summary. PowerPoint page 4.

Nie, L. (2018). *Running a two-way ANOVA through multiple linear regression in SPSS*. Purdue Department of Statistical Consulting.

Noble, R., Phillips, B. Culp III, K., Powell, N. (2018). *Kentucky 4-H Minimizes Barriers to STEM Education*, ProQuest Dissertations and Theses.

Noone, R., & United States, Department of Commerce, Office of the Chief Economist, issuing body (2017) *Women in STEM: 2017 Update.* (ESA issue brief; 17-06).

Organization for Economic Co-operation and Development, (2015). *Early Gender Gaps Drive Career Choices and Employment Opportunities.* Paris, France: OECD Publishing

Overbey, T.A., Dotson, D.S., Meyers-Labadie, M., (2017). Public librariers and high education combining efforts to create quality STEM children's programs. *Public Library Quarterly, 37(1), 21-35.*

Price, P.C., Jhangiani, R.S., Chiang, I.A. (2015). *Research methods in Psychology: 2nd Canadian Edition*. BCcampus OpenEd. Open.bccampus.ca.

Privitera, G. J. (2018). *Statistics for the behavioral sciences*. Thousand Oaks, CA: SAGE Publications.

Robelen, E.W. (2012). STEM Gender Gap pronounced in U.S. (Science, Technology, Engineering, and Mathematics). *Education Week, 31(35), 8.*

Rosen, Larry D.(n.d). Rewired: Understanding the iGeneration and the Way They Learn, Palgrave Macmillan Limited, 2010. ProQuest Ebook Central, http://ebookcentral.proquest.com/lib/purdue/detail.action?docID=515055.

Sadler, P.M., Sonnert, G., Hazari, Z., Tai, R., (2012). Stability and volatility of STEM career interest in high school: A gender study. *Journal of Science Education, 96(3), 411-427.*

Sage, R., Vandagriff, J., & Schmidt, J., (2018). Building life skills and interest in STEM through rural 4-H robotics camps. *Journal of Human Sciences and Extension, 6(1), 18-35.*

Sallie, Jeff, Peek, Gina G. (2014). Fitting the Framework: The STEM Institute and the 4-H Essential Elements. *Journal of Extension, 52(2), 13.*

Samuel, A. (2006). *Make and Test Projects in Engineering Design Creativity, Engagement and Learning*. Springer London.

Savage, J. (2016). How competent is your workforce? In the third installment of our new series focusing on skills and training, John Savage of the national fluid power centre (NFPC) discusses the importance of competence-based assessment to enable best practice across all areas of industry. *British Plastics & Rubber,* 33.

Schmuck, C. (2017). *Women in STEM disciplines.* The Yfactor 2016 Global Report on Gender in Science, Technology, Engineering and Mathematics.

Simon, M.K., Goes, J. (2013), *Dissertation and scholarly research: Recipes for success*. Seattle, WA: Dissertation Success LLC.

Shea, J. (1984). *Education for the manufacturing world of the future*. Washington D.C.: The National Academic Press.

Statwing, (n.d.). Interpreting residual plots to improve your regression. Retrieved October 29, 2018, from http://docs.statwing.com/interpreting-residual-plots-to-improve-your-regression/

STEM 101: Intro to tomorrow’s jobs. (2014). *Occupational Quarterly*, *1*, 1-4.

Tomoki Saito, Ilman Anwari, Lely Mutakinati, Yoshisuke Kumano. (2016). A Look at Relationships (Part I): Supporting Theories of STEM Integrated Learning Environment in a Classroom - A Historical Approach. *Journal of K-12 STEM Education 2*(2), 51-61.

Tuckman, B. W. (1999). *Conducting educational research* (5th ed.). New York: Wadsworth Group.

USDA & NIFA, (2015). National 4-H & Youth Development Outcomes & Indicators. Retreived from: https://nifa.usda.gov/sites/default/files/resource/ 4h%20%26%20Youth%20National%20Outcomes%20Listing.pdf

Walton, G.M., & Spencer, S.J. (2009). Latent ability: Grades and test scores systematically underestimate the intellectual ability of negatively stereotyped students. *Psychological Science, 20(9), 1132-39*.

Wan Husin, Wan Nor Fadzilah, Mohamad Arsad, Nurazidawati, Othman, Oziah, Halim, Lilia, Rasul, Mohamad Sattar, Osman, Kamisah, & Iksan, Zanaton. (2016). Fostering Students' 21st Century Skills through Project Oriented Problem Based Learning (POPBL) in Integrated STEM Education Program. *Asia-Pacific Forum on Science Learning and Teaching, 17*(1), 1-18.

Wang, & Degol, (2013). Motivational pathways to STEM career choices: Using expectancy-value perspective to understand individual and gender differences in STEM fields. *Developmental Review, 33(4), 304-340.*

What is fluid power. (2016). Retrieved 2017-2-7, from wwww.nfpa.org

What is Project-Based Learning? (2018). Defined STEM Blog. Retrieved September 4, 2018, from https://www.definedstem.com/blog/what-is-project-based-learning/

Yaffe, Deborah. (2018). Small-town STEM: Rural districts bolster math and science programs with new funding sources, technology and powerful partnerships. *District Administration, 54*(9), 38-42.

APPENDIX A. SUPPLEMENTAL MATERIALS

Supplemental materials for the 4-H NFPA Fluid Power Challenge including portfolio checklist, mid-project checklist, rules, and photos depicting these events.

NFPA Fluid Power ACTION Challenge

Portfolio Checklist

SCHOOL ______________________________

PORTFOLIO CHECK LIST (insert as index in your portfolio)

Page	Describe context and restate the problem
Page	Describe criteria for success
Page	Sketches of two possible solutions for the device
Page	Orthographic drawing of structural components of the device
Page	Isometric drawing of a portion of the device
Page	Materials list for the device including consideration of alternatives
Page	Consideration of principles of structural strength and stability
Page	Explanation of placement of fluidic components
Page	Evaluation of prototype including conclusions from making it

NFPA Fluid Power Action Challenge

Mid-Project Checklist

- Please prepare the following action items before the mid-project review with a NFPA Challenge Host.
- Tasks will be graded on a simple yes/no scale if they are complete or not.
- 1 point will be earned for each completed action item.
- The total points earned will be added to that team's final portfolio rubric score on challenge day.

Team Name:____

Team Member #1______________________
Team Member #2______________________

Team Member #3______________________
Team Member #4______________________

*The below portion will be filled out by the NFPA Challenge Host during the mid-project checkup.

	Complete?	
Task	**Yes**	**No**
Summary of team progress		
Description of initial concept		
Preliminary outline of the division of labor		
1 rough isometric sketch of portion of device		
1 rough orthographic drawing of portion of device with dimensions		

Total Points Earned = __________Pts

NFPA Education and Technology Foundation

Rules for Challenge

SAFETY is our number one concern

1. **ALL motion must be controlled using fluid power**
   - *If your team manufactures a device that* ***only works when it is stabilized by hand(s)*** *then* ***only 50% of the "moving object" score will count.***
   - *If your team* ***breaks the device*** *during the allocated 2 minutes, then your team can repair it during those 2 minutes and* ***subsequent 'moving object" scores will count 50%.***
   - *If your device is* ***touched by hand in any other way,*** *then* ***the "moving object" score will be zero.***
2. Use your materials wisely. Only limited numbers of components are provided for exploration and building prototypes, and at the Challenge
3. Only use the tools provided in your kit
4. Document everything in your portfolio. Remember to bring two copies of your portfolio to the Challenge
5. On Challenge Day, all materials will be provided except for tools. Bring only the tools kit provided on the Workshop Day to the Challenge
6. Use your time wisely – the competition begins at 1pm
7. Teachers will draw numbers at registration on Challenge Day to determine order of teams for competition
8. Teachers, adults and volunteers are there to observe the students, not design, document or build prototypes or finalized design

HAVE FUN!! WORK WELL!!

APPENDEX B. SURVEY INSTRUMENTS

Fluid Power Challenge Survey

This competition invites students to solve a real-life engineering problem using fluid power (hydraulic and pneumatic) technology. Fluid power is the ability to move large or heavy objects using compressed fluid or air. Please fill out the survey on what you knew before and what you have learned from this event.

1. Please answer each of the questions below based on your experience before and after the 4-H NFPA Fluid Power Challenge.

Scale: 1=Not at all 2=Not much 3=Somewhat 4=Pretty Much 5=Very

	Before doing the challenge				
Engineers are problem-solvers. How motivated are you to learn how to think like an engineer?	1	2	3	4	5
Do you believe that team-work is an important skill to develop for your future?	1	2	3	4	5
Which of these words make you think of being an engineer? (circle all that apply)	IMPROVE MANAGE	FIX IDENTIFY	GIVE UP MEDICATE	CHOOSE IGNORE	
How interested are you in a career in science, technology, engineering and mathematics?	1	2	3	4	5
Name four ways that fluid power is used?	1. ________ 2. ________ 3. ________ 4. ________				
I am interested in learning more about fluid power and how it works.	1	2	3	4	5
I am interested in a career in fluid power or robotics.	1	2	3	4	5

2. List four of your favorite things about the Fluid Power Challenge Competition
   a. ____________________
   b. ____________________
   c. ____________________
   d. ____________________

3. How many years have you taken part in the 4-H Fluid Power Challenge? ____________

4. What is your gender? ____________________

4-H Common Measures
4-7th Grade Science Items

Dear Participant:

You are being given this survey **because you are part of a 4-H program or project,** and we are surveying young people like you to learn about your experiences.

This survey is voluntary. If you do not want to fill out the survey, you do not need to. However, we hope you will take a few minutes to fill it out because your answers are important.

This survey is private. No one at your school, home, or 4-H program or project will see your answers. Please answer all of the questions as honestly as you can. If you are uncomfortable answering a question, you may leave it blank.

This is not a test. There are no right or wrong answers, and your answers will not affect your participation or place in the program in any way.

Thank you for your help!

Section I: Tell us about your 4-H Experience

Please select the responses that best describe you.

1. **How many years have you been participating in 4-H?** (Mark one box ☒.)
☐ I am not in 4-H or this is my first 4-H experience
☐ This is my first year
☐ This is my second year
☐ Three or more years

2. **Which one of the following best describes how many hours you typically spend in 4-H programs/projects each week?** (Mark one box ☒.)
☐ Less than one hour
☐ Between one and three hours
☐ More than three hours

3. **Which of the following best describes how you are involved in 4-H?** (Mark each box ☒that applies to you.)
☐ Clubs
☐ Camps
☐ After-school programs
☐ In-school programs
☐ Local fairs/events
☐ Community service projects
☐ Working on my projects at home
☐ Other

Section II: Interest, Engagement, and Attitudes

1. **Please indicate to what extent you agree or disagree that your experience in this 4-H program or project has resulted in the following outcomes.** (Select one response in each row by marking the appropriate box ☒.)

In this 4-H program or project…	***Strongly Agree***	***Agree***	***Disagree***	***Strongly Disagree***
I like to see how things are made or invented	☐	☐	☐	☐
I like experimenting and testing ideas	☐	☐	☐	☐
I get excited about new discoveries	☐	☐	☐	☐
I want to learn more about science	☐	☐	☐	☐
I like science	☐	☐	☐	☐
I am good at science	☐	☐	☐	☐
I would like to have a job related to science	☐	☐	☒	☐
I do science activities that are not for school	☐	☐	☐	☐

Section III: Science Skills, Abilities, Applications

2. **Please indicate which of the following applies to you by choosing yes or no.** (Select one response by marking the appropriate box ☒.)

In this 4-H program or project …	**Yes**	**No**
I can do an experiment to answer a question	☐	☐
I can tell others how to do an experiment	☐	☐
I can explain why things happen in an experiment	☐	☐

Section IV: Tell us about You

Please select the responses that best describes you for the follow the questions.

3.	**How old are you?**	
	_______	Age (in years)
4.	**What grade are you in?**	
	_______	Grade
5.	**Which of the following best describes your gender?** (Mark one box ☒.)	
	☐	Female
	☐	Male
6.	**Which of the following best describe your race?** (Mark each box ☒that applies to you.)	
	☐	American Indian or Alaskan Native
	☐	Asian
	☐	Black or African American
	☐	Native Hawaiian or Other Pacific Islander
	☐	White
7.	**Which of the following best describe your ethnicity?** (Mark one box ☒.)	
	☐	Hispanic or Latino
	☐	Not Hispanic or Latino
8.	**Which of the following best describes the primary place where you live?** (Mark one box ☒.)	
	☐	Farm
	☐	Rural (non-farm residence, pop. < 10,000)
	☐	Town or City (pop. 10,000 – 50,000)
	☐	Suburb of a City (pop. > 50,000)
	☐	City (pop. > 50,000)
9.	**What county do you live in?**	
	_______________	County
10.	**Do you have a parent or guardian(s) in the military?** (Mark each box ☒ that applies to you.)	
	☐	Air Force
	☐	Army
	☐	Coast Guard
	☐	Marines
	☐	National Guard
	☐	Navy
	☐	Reserve
	☐	I do not have a parent or guardian(s) in the military

APPENDEX C. RAW DATA

Research Questions #1 Descriptive Statistics					
Dependent Variable: How interested are you in a career in science, technology, engineering and mathematics?					
Years	Gender	Pre/Post	Mean	Std. Deviation	N
First Year	Male	Pre	4.25	.856	16
		Post	3.80	1.146	15
		Total	4.03	1.016	31
	Female	Pre	3.53	1.125	17
		Post	3.00	.816	4
		Total	3.43	1.076	21
	Total	pre	3.88	1.053	33
		post	3.63	1.116	19
		Total	3.79	1.073	52
Second Year	Male	Pre	4.22	.972	9
		Post	3.60	1.140	5
		Total	4.00	1.038	14
	Female	Pre	3.50	.577	4
		Post	2.00	1.000	3
		Total	2.86	1.069	7
	Total	Pre	4.00	.913	13
		Post	3.00	1.309	8
		Total	3.62	1.161	21
Third Year	Male	Pre	4.50	.837	6
		Post	4.33	.816	6
		Total	4.42	.793	12
	Female	Pre	3.50	1.000	4
		Post	3.33	1.155	3
		Total	3.43	.976	7
	Total	Pre	4.10	.994	10
		Post	4.00	1.000	9
		Total	4.05	.970	19
Total	Male	Pre	4.29	.864	31
		Post	3.88	1.071	26
		Total	4.11	.976	57
	Female	Pre	3.52	1.005	25
		Post	2.80	1.033	10
		Total	3.31	1.051	35
	Total	Pre	3.95	.999	56
		Post	3.58	1.156	36
		Total	3.80	1.072	92

Research Question #2 Descriptive Statistics				
Dependent Variable: Interest, Engagement, and Attitudes Questions from Common Measures				
Gender	Residence	Mean	Std. Deviation	N
Male	Rural (Farm/Non-Farm)	3.1592	.55215	13
	Town	3.0736	1.07991	11
	Urban (Suburban/City)	2.7871	1.28122	7
	Total	3.0448	.92761	31
Female	Rural (Farm/Non-Farm)	3.0350	.64117	4
	Town	3.1117	.48963	6
	Urban (Suburban/City)	2.2225	.46999	4
	Total	2.8357	.63334	14
Total	Rural (Farm/Non-Farm)	3.1300	.55560	17
	Town	3.0871	.89674	17
	Urban (Suburban/City)	2.5818	1.06411	11
	Total	2.9798	.84544	45

Research Question #3 Descriptive Statistics for Fluid Power Career Questions					
Dependent Variable: Fluid power career questions					
Gender	Years	Pre/Post	Mean	Std. Deviation	N
Male	First Year	pre	3.5000	.82375	15
		post	3.5000	1.04881	16
		Total	3.5000	.93095	31
	Second Year	pre	3.8333	.81650	6
		post	3.6429	1.02933	7
		Total	3.7308	.90405	13
	Third Year	pre	3.9167	.91742	6
		post	3.6667	1.08012	6
		Total	3.7917	.96433	12
	Total	pre	3.6667	.83205	27
		post	3.5690	1.01528	29
		Total	3.6161	.92437	56
Female	First Year	pre	3.4091	1.06813	11
		post	2.0833	.73598	6
		Total	2.9412	1.14404	17
	Second Year	pre	3.8333	.76376	3
		post	2.3333	.76376	3
		Total	3.0833	1.06849	6
	Third Year	pre	3.5000	.70711	2
		post	3.8333	.28868	3
		Total	3.7000	.44721	5
	Total	pre	3.5000	.94868	16
		post	2.5833	.97312	12
		Total	3.1071	1.04843	28
Total	First Year	pre	3.4615	.91568	26
		post	3.1136	1.15400	22
		Total	3.3021	1.03523	48
	Second Year	pre	3.8333	.75000	9
		post	3.2500	1.11181	10
		Total	3.5263	.97857	19
	Third Year	pre	3.8125	.84251	8
		post	3.7222	.87003	9
		Total	3.7647	.83137	17
	Total	pre	3.6047	.86985	43
		post	3.2805	1.09000	41
		Total	3.4464	.99098	84