Fall 12-2014

Development of Workforce Skills: Student Perceptions of Mentoring in FIRST Robotics

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The University of Southern Mississippi

DEVELOPMENT OF WORKFORCE SKILLS: STUDENT PERCEPTIONS OF MENTORING IN FIRST ROBOTICS

by

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Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

December 2014

ABSTRACT

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In today's global economy, new workforce competencies are needed for success at both individual and societal levels. The new workforce skills extend beyond basic reading, writing, and arithmetic to include higher order processes such as critical thinking and problem solving. Technical job opportunities have grown by approximately 17%, yet the United States continues to decline in science, technology, engineering and mathematics (STEM) disciplines. Further, U.S. students earn average or below average test scores when compared to other developed countries. Researchers cite the need to incorporate the learning of workplace skills into secondary education curriculum, and advocates call for new teaching methodology and contextual experiences to enhance learning. A popular and expanding method for teaching students is the use of technical mentors to develop workforce skills. Education studies demonstrate learning is a social activity, and mentors can play a vital role in understanding and learning skills. The FIRST Robotics program relies heavily on mentor expertise for student instruction. This study uses FIRST Robotics teams as a population to investigate student perception of the effectiveness of mentors on the development of workforce skills. Findings show students perceive mentors have a positive effect on the development of workforce skills, and, furthermore, students' perceptions of mentors impact student learning.

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December 2014

DEDICATION

In memory of

Kimmy Melton

- A beautiful example of life lived to its fullest

ACKNOWLEDGMENTS

I would like to thank my dissertation chair, Dr. Heather Annulis, and committee members, Dr. Cyndi Gaudet, Dr. Patricia Phillips, and Dr. Dale Lunsford, for their advice and expertise during my classes and the dissertation process. I would like to extend a special and huge thank you to Dr. Annulis for her support, patience, and positive attitude. I would like to thank three friends and tireless supporters of technology in education, Dave Lavery, Randall Hicks, and Chris Copelan. Their vision and effort have helped thousands of students nationwide and have created many engineers and future engineers. Thank you also to the NASA Robotics Alliance Working Group, the NASA Office of Education, and the teams at Stennis Space Center, Marshall Space Flight Center, and Headquarters, for providing an opportunity to work with STEM education.

Thank you to FIRST Robotics and the Brandeis University Center for Youth and Communities for their help and for allowing me to use their survey instrument. Thank you also to Macey Wallace for serving as my research assistant.

Most importantly, I would like to thank my family for their support during the long years of classes, studying, research, and writing: my parents, Smiley and Alan Veal, for teaching me that education is important; my brother, Casey Veal, for keeping everything in perspective; and my smart and beautiful daughters, Macey and Avis, who put up with my long hours of studying. I would like to give a special thank you to my husband, Butch, for his support and love throughout this journey.

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INTRODUCTION

The rapid expansion of technology and the rise of a global economy create the need for new occupations and new job skills (Friedman, 2005). Today's workers require different skillsets than past generations, such as, "forging relationships rather than executing transactions, tackling novel challenges instead of solving routine problems, and synthesizing the big picture rather than analyzing a single component" (Pink, 2006, p. 40). Recent studies cite the need for a strong technical workforce in order for the United States to maintain its place as a world leader (Carnegie, 2009; Friedman, 2005; Jacobs, 2010; National Academy of Sciences, 2007). The National Commission on Mathematics and Science Teaching (2000) reports that knowledge work is replacing low-end work and that 60% of new jobs in the early 21st Century will require skills that only 20% of the current workforce possess. A report by the National Academy of Sciences (2007) states that without "high quality, knowledge-intensive jobs and the innovative enterprises that lead to discovery and new technology, our economy will suffer and our people will face a lower-standard of living" (p. 1). Twenty years ago, a U.S. Department of Labor (USDOL; 1991) study collected information from businesses about skills needed for the workforce. The resulting skills included critical thinking, decision-making, problem solving, and understanding and applying complex relationships. Research supports the need for a strong technical workforce but there is concern that the current education system does not provide students with the proper skillset (Carnegie, 2009; Wagner, 2008). Workforce development is necessary for today's workers to develop the skills needed for success in the global economy (Elkeles & Phillips, 2007; Wagner, 2008).

"Workforce development has evolved to describe any one of a relatively wide range of national and international policies and programs related to learning for work" (Jacobs, 2002, p. 3). Jacobs defines workforce development as societal in nature and ranging from elementary school to on-the-job training. To understand what is necessary for workforce development, one must understand the current state of the U.S. workforce.

The term STEM is an acronym for science, technology, engineering, and mathematics, and refers to any field of technical study. There are varied definitions for STEM jobs, but the U.S. Department of Commerce (2011) defines STEM jobs as technical and professional occupations in the areas of engineering, computer science, life science, and physical science. The STEM occupations require a background in the subject areas of mathematics and science, and competence in the application of related principles. The U.S. Department of Commerce states STEM occupations are expected to grow by 17% through 2018 while non-STEM jobs will grow by about 10%. A STEM worker earns roughly 26% more than non-STEM counterparts (Sturtevant, 2008; USDOC, 2011). These figures support the increased need for highly trained, knowledgeable workers. Conversely, the United States continues to experience a decline in STEM graduation rates and workers. Approximately 6% of U.S. undergraduates major in engineering, compared to 12% in Europe, 20% in Singapore, and over 40% in China. The rate of 6% is the second lowest among developed countries (National Academy of Sciences, 2007). Furthermore, STEM college graduation rates in the U.S. rank even lower. The low rate of STEM graduates forces many U.S. companies to hire foreign engineers. These factors impact the ability of the United States to compete in a global economy that depends on innovation and creativity for success (Friedman, 2005, National Academy of Sciences, 2007).

Friedman (2005) argues that the world is changing, and the characteristics that made the United States an economic world leader in the past will not keep it successful in the future. The advent of computers and the Internet have made the world seem smaller and, in essence, have “flattened” the world. The conditions causing the most change in the workplace in the past 30 years include the globalization of commerce and the use of technology to perform jobs (Karoly & Panis, 2004; USDOL, 1991); therefore, "yesterday's education is not sufficient for today's learner" (North Central Regional Educational Library [NRCEL], 2003, p. 4). Mathematics and science are subjects that build on prior knowledge. For example, a student cannot effectively learn algebra without first understanding numerical concepts (Sturtevant, 2008). The concepts should be mastered in upper elementary and middle school. However, the Third International Mathematics and Science Study (TIMSS), which tests students in 41 countries, notes a rapid decline in U.S. children’s STEM abilities as they age. The U.S. fourth graders were among the top in the world in the mathematics assessment, but by high school graduation ranked among the last (Mullis, Martin, Foy, & Arora, 2012). In correlation, interest in mathematics and science declines as students matriculate through high school and college (Sturtevant, 2008). Sturtevant (2008) asserts that because STEM subjects are hierarchical in nature, once students drop out of a pipeline, they do not return. The challenge for U.S. educators is to keep students interested in STEM throughout elementary and secondary school and then through college. Advocates state that new skills and new teaching methodologies are required to maintain student interest (Carnegie, 2009; Friedman, 2005; National Academy of Sciences, 2007). Although the world has changed rapidly in the past 50 years, the U.S. education system remains relatively unchanged (Jacobs, 2010; Wagner, 2008).

The problems with the antiquated education system surface in achievement studies such as TIMSS. Another international study, the Program for International Student Achievement (PISA), tests 15 year-old students in reading, mathematics, and science on a 3-year cycle (OECD, 2012). The PISA, designed to test real world application of mathematical knowledge rather than curriculum, is conducted through the Organization for Economic Cooperation and Development (OECD), a group of 34 industrialized nations (IES, 2009; Wagner, 2008). In 2009, the United States reported average scores in reading and science and below average scores in mathematics. Among the 34 countries tested, the United States scored lower than 17, higher than five, and about the same as 11 others. U.S. Secretary of Education Arne Duncan states:

> The big picture from PISA is one of educational stagnation, at a time of fast-rising demand for highly-educated workers. The mediocre performance of America's students is a problem we cannot afford to accept and cannot afford to ignore. In a highly-competitive knowledge-based economy, maintaining the educational status quo means America's students are effectively losing ground. (Duncan, 2010, para. 19-20)

Both TIMSS and PISA evaluations indicate U.S. students are not competing globally. In addition to the national evaluations, several organizations divide student test scores by state to analyze trends and determine gaps in student groups (IES, 2013). Two states typically have the lowest test scores, Mississippi and Louisiana. The present study will focus on mentoring as a method of workforce development in these two low performing states.

The National Assessment of Educational Progress (NAEP) rates Mississippi at 49 out of 52 at a state level (includes 50 U.S. states, District of Columbia, and Department of Defense Education Activity schools) in science and 48 out of 52 in mathematics (IES, 2012a, 2012b, 2013). As shown in Table 1, NAEP assessments for mathematics rates 39% of Mississippi eighth graders below basic proficiency, 40% with basic proficiency, and 21% as proficient or advanced. For science, 53% of students rate below basic, 29% rate basic, and 18% rated proficient. The state percentage of students qualifying as advanced for science rounds to zero (IES, 2013).

Table 1

Mississippi and Louisiana Eighth Grade Student Performance in Mathematics and Science

	Mississippi		Louisiana	
Achievement Level	Mathematics	Science	Mathematics	Science
Below Basic Proficiency	39%	53%	36%	45%
Basic Proficiency	40%	29%	43%	33%
Proficient	18%	18%	18%	22%
Advanced	3%	0%	3%	1%

Note: Based on information from the “The Nation’s Report Card: State Snapshot Report” by IES, 2013.

Louisiana ranks slightly higher than Mississippi in student performance in mathematics and science. The National Assessment of Educational Progress reports Louisiana eighth grade students at 44 out of 52 states in science and 46 out of 52 in mathematics (IES, 2012a, 2012b, 2013). The NAEP assessments for mathematics rate 36% of Louisiana eighth graders below basic proficiency, 43% with basic proficiency, and 21% as proficient or advanced. For science, 45% of the students rate below basic, 33% percent rate basic, and 22% percent rate proficient. Only 1% of Louisiana's tested population rank as advanced in science.

Problem Statement

As evidenced by national and international assessments, U.S. students test poorly in the subjects that are critical to function successfully in today's global economy. Furthermore, Mississippi and Louisiana students rank almost last within the nation. Research states that skills such as problem solving, critical thinking, and application of knowledge are key for success in today's workforce (Friedman, 2005; Jacobs, 2010; Karoly & Panis, 2004; National Academy of Sciences, 2007; NCREL, 2003; Partnership for 21st Century Skills, 2009a; USDOL, 1991). Cognitive and affective learning occur in stages or levels, with each level building on comprehension of the lower level (American Society for Training and Development, 2006). Students that cannot meet basic competency levels in STEM subjects do not have the skills to synthesize and apply knowledge to real world problems and will have difficulty succeeding in today's workforce.

The use of mentor-based programs as a method of instruction has grown in recent years due in part to research that notes the positive contributions of mentors in the lives of youth (Dubose & Rhodes, 2006). Mentors can model successful behaviors, including workforce skills (Karcher, 2008; Rhodes & Lowe, 2008). Some mentoring programs are developmental, while others, such as instrumental mentoring, may be more effective in teaching workforce skills (Karcher, 2006). New types of mentoring are gaining popularity, and evidence shows that these mentoring methods may promote higher order learning (Karcher, 2008; Komosa-Hawkins, 2009; Randolph & Johnson, 2008). Mentors can provide technical and business content knowledge and model workforce skills for students.

Purpose of Study

Because U.S. students, specifically those in Mississippi and Louisiana, are performing below average in mathematics and science skills, different methods, such as mentoring, can enhance STEM learning and comprehension. The purpose of the present study is to determine the effectiveness of mentoring as a method of developing four specific STEM workforce skills for high school students participating in the FIRST Robotics program. The study will measure effectiveness by student perception. The FIRST (For Inspiration and Recognition of Science and Technology) Robotics program will serve as a basis for this research. The FIRST program is an extracurricular technology program that teaches real-world problem solving through a robotics competition and includes programs for students ages six through eighteen. Mentoring is a cornerstone of the FIRST program, and FIRST actively seeks adult mentors for teams.

Significance of Study

The present study will add to the body of knowledge on the perceived effectiveness of mentoring as a method of workforce development. Literature suggests mentoring is valuable but relatively little evaluation of programs exists to create a set of best practices (Karcher, Kuperminc, Portwood, Sipe, & Taylor, 2006). The number of mentoring programs total in the thousands but the "research base that is necessary to inform the practice of mentoring, by comparison, lags behind" (DuBois & Rhodes, 2006, p. 647). The FIRST Robotics program targets school age students in a STEM setting. The mentors in FIRST Robotics focus on training students to apply mathematics and science skills to solve problems and to think creatively (U.S. FIRST, 2013c). More research is needed to evaluate not only how the mentor exposes the student to new ideas but also how effectively the mentor raises the student's interest in learning (Rhodes, Spencer, Keller, Liang, & Noam, 2006). Mentoring research tends to seek information on mentoring from the adult or mentoring perspective rather than the student or mentee perspective (Dubois, Doolittle, Yates, Silverhorn, & Tebes, 2006).

Research Objectives

This study addresses the following research objectives:

RO1: Describe FIRST students who participate on a robotics team by identifying team name and number, school name, perceived interest in STEM, number of years on a robotics team, and if mentored or non-mentored.

RO2: Determine FIRST student perceptions of the mentor's role in developing workforce skills, specifically: (a) problem solving, (b) critical thinking, (c) teamwork, and (d) communication.

RO3: Compare perceived differences between mentored and non-mentored FIRST student workforce skills, specifically: (a) problem solving, (b) critical thinking, (c) teamwork/ collaboration, and (d) communication.

Conceptual Framework

The purpose of this study is to determine the effectiveness of mentoring as a method for development of workforce skills as perceived by FIRST Robotics high school students. The foundational theories of the research include Piaget's theory of constructivism, Vygotsky's zone of proximal development, and Papert's theory of constructionism. The theories stress the importance of interaction with the environment as a basis for learning and knowledge retention. Learning is a social activity requiring input from and interaction with the surrounding world. Students in this study interact with adult mentors to learn about STEM content and workforce skills. Mentors can play a vital role in a student's understanding of and ability to use skills necessary for success in the workplace (Dubois & Rhodes, 2006; Karcher et al., 2006; Lave & Wenger, 1991). The proposed research will determine if students perceive that mentoring develops the four workforce skills of problem solving, critical thinking, teamwork, and communications skills. The research will describe the students who participate in FIRST Robotics to include team number, grade level, number of years in robotics, and if they worked with mentors. Then, the research will determine if students perceive that working with a mentor developed their workforce skills. Finally, the research will compare mentored FIRST students' to non-mentored students' perceptions of workforce skills. The study will analyze the students' perceived effectiveness of mentoring on the development of four specific workforce skills.

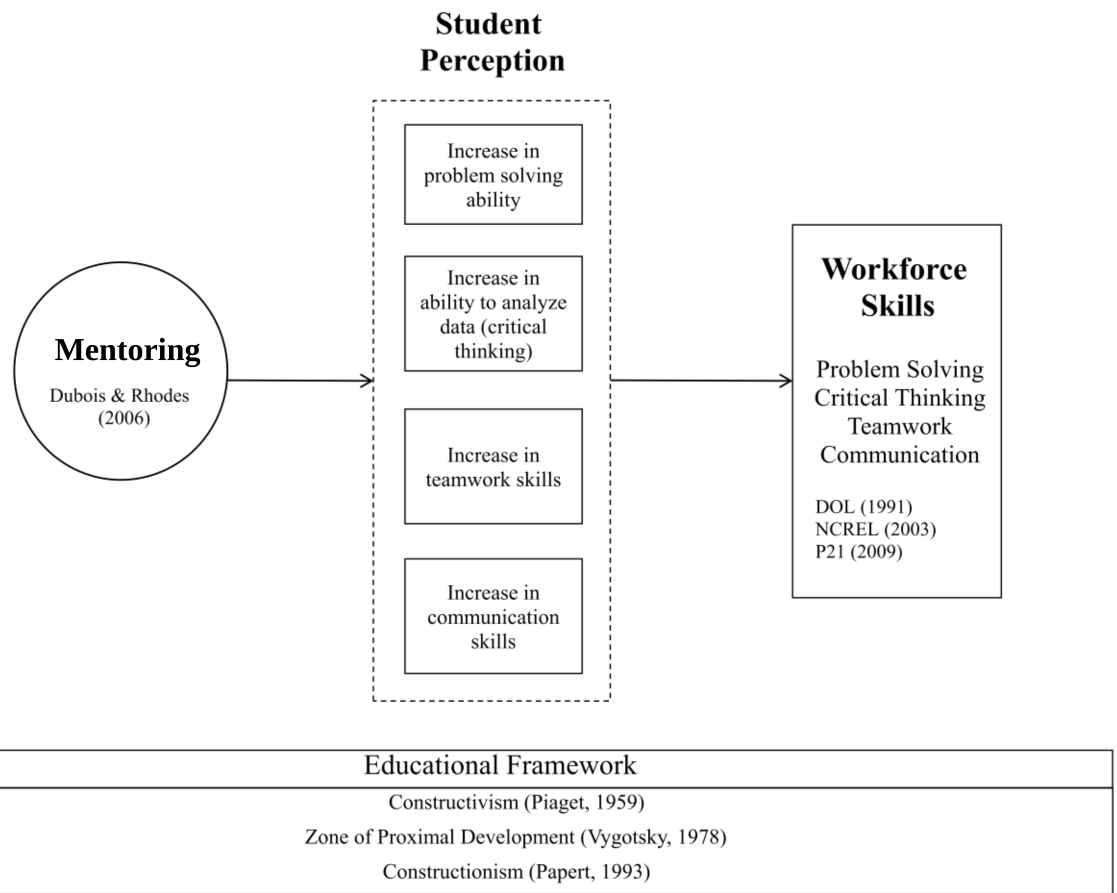

Figure 1. Conceptual framework for the study of student perceptions of the effectiveness of mentoring as a method for development of four workforce skills. The four workforce skills are compiled from studies by the U.S. Department of Labor (USDOL), the North Central Regional Educational Library (NCREL), and the Partnership for 21st Century Skills (P21).

Limitations

This study measures student perceptions of the effectiveness of mentoring on the development of four workforce skills; therefore, survey data was based on students' perceptions only. No assessment of test scores or student grades was used due to privacy issues. The researcher had a working relationship with several of the participating robotics teams and attempted to control bias by ensuring all surveys were anonymous, by using an impartial assistant for data entry, and by using a facilitator for qualitative data collection. Because the population involved minors, a parent or guardian's approval for participation was required. Parents had the option to prohibit their children's participation in the study thereby lowering response rate. Another limitation is that students who choose to participate on a robotics team as an extracurricular activity may be predisposed to enjoy or excel in STEM subjects. Additionally, robotics students may have prior knowledge of applying workforce skills.

Delimitations of Study

The population was limited to high school students (ninth through twelfth grades) who participate on a FIRST Robotics Team in Mississippi or Louisiana due to time constraints. The sample size of this study was relatively small, covering the robotics teams in two states. This may be a limitation because a small or geographically limited sample size may not provide enough data to detect subtle dynamics in the mentoring relationship, and the study might not provide the confidence needed to generalize the results to a larger population (Dubois et al., 2006).

Definition of Key Terms

1. *STEM:* Science, Technology, Engineering, and Mathematics (National Academy of Sciences, 2007).
2. *Workforce Skills:* A combination of basic knowledge and applied skills that are deemed important for success in today's global economy; includes skills such as effective communication, critical thinking, problem solving, and technical literacy (P21, 2006).
3. *Mentor*: A relationship between an adult and a child or student that promotes positive youth development by providing motivation, structure, and guidance while supporting the child as an agent of his or her own growth (Dubois & Rhodes, 2006).
4. *Constructivism:* A view of cognitive development in which a person builds an understanding of reality based on interaction with the world; the person's reality is based on his or her experiences (Slavin, 1997).
5. *Constructionism:* A view of cognitive development related to constructivism; constructionism asserts that students use concrete methods, namely technology and computers, to reach higher levels of understanding (Sullivan & Moriarty, 2009). Knowledge is constructed in the mind through active learning with concrete tools such as robots and computers (Lindh & Holgersson, 2007).
6. *Zone of Proximal Development:* The level of development immediately above a person's present level; tasks within this zone are ones that the person cannot

do alone but can do with aide of an adult or a more competent peer (Slavin, 1997; Vygotsky, 1978).

7. *FIRST Robotics*: For Inspiration and Recognition of Science and Technology; a not-for profit organization whose mission is to "inspire young people to be science and technology leaders, by engaging them in exciting mentor-based programs that build science, engineering and technology skills, inspire innovation, and foster well-rounded life capabilities including self-confidence, communication, and leadership" (U.S. FIRST, 2013a).
8. *Problem Solving Skill*: The ability to "solve different kinds of non-familiar problems in both conventional and innovative ways" and to make judgments and decisions (P21, 2009b, p. 4).
9. *Critical Thinking Skill:* Skill that uses rationalization and evaluates reasons, then aligns thoughts and actions with the evaluation (Perkins & Mincemoyer, 2001).
10. *Collaboration/ Teamwork Skill:* "Cooperative interaction between two or more individuals working together to solve problems, create novel products, or learn and master content" (NCREL, 2003, p. 47).
11. *Communication Skill:* The skill that "is the generation of meaning through exchanges using a range of contemporary tools, transmissions, and processes" (NRCEL, 2003, p. 56).

Summary

Workforce development is becoming increasingly important as the United States competes in a global economy. Many studies document the need for a stronger focus on applied skills learned through STEM subjects (Jacobs, 2010; National Academy of Sciences, 2007; USDOC, 2011; USDOL, 1991; Wagner, 2008). The studies state, in addition to basic skills, workers (and future workers) need to be able to apply skills to higher order tasks like critical thinking, problem solving, innovation, and collaboration. Educational researchers like Piaget and Vygotsky emphasize that learning is a social activity and interaction with society and the environment stimulates cognitive development. Workforce development is not limited to workers but extends to many levels of society, including school age children. Jacobs (2002) suggests students will become future workers, so workforce development should begin during elementary and secondary school. Researchers cite methods to develop higher order thinking skills for students (Jacobs, 2010; Vollstedt, 2005; Wagner 2008). One method is mentoring of high school students by a more knowledgeable adult (Dubois & Rhodes, 2006; Lave & Wenger, 1991; MacDonald & Sherman, 2007; Vygotsky, 1978). The study utilizes survey data of students' perceptions. The purpose of this study is to measure student perceptions of the effectiveness of mentoring on learning workforce skills. The four workforce skills of problem solving, critical thinking, teamwork, and communication are based on a seminal report from the U.S. Department of Labor's Secretary's Commission on Achieving Necessary Skills (SCANS) (1991) and verified later by research from the Partnership for 21st Century Skills (P21) (2009a, 2009b) and the North Central Regional

Education Library (NCREL) (2003). FIRST Robotics teams in Mississippi and Louisiana serve as the population of the study.

Educational theory provides evidence that learning is a social activity and students learn through interaction with others. Further studies show that mentoring is a valid method of teaching as it provides assisted learning and support. Mentoring provides experiential learning opportunities and allows students to practice workforce skills with the help of an older, more experienced teacher. A review of educational theory and mentoring provides a possible framework for teaching critical workforce skills to high school students.

CHAPTER II

LITERATURE REVIEW

"Without high-quality, knowledge-intensive jobs and the innovative enterprises that lead to discovery and new technology, our economy will suffer and our people will face a lower standard of living" (National Academy of Sciences, 2007, p. 1). The National Academies' Committee on Prospering in the Global Economy of the 21st Century researched the effects of globalization on the United States and the resulting need for innovation in education. This chapter investigates theories in learning and provides a framework for study in current workforce development efforts.

Several forces, including outsourcing, offshoring, computers, and the Internet, have combined to "flatten" the world and to allow smaller countries to become economically competitive (Friedman, 2005; National Academy of Sciences, 2007). To remain competitive in the global market, today's workforce must have a more varied and extensive set of skills than existed thirty years ago. Unskilled jobs made up 80% of the market in 1950. Today, about 85% of all jobs are considered skilled. For example, machining and lathing uses computer-numerically-controlled (CNC) equipment, a technology that requires knowledge of computer programming, calculus, and engineering design (National Commission on Mathematics and Science, 2000). The skill set for today's workforce is dramatically different than 30 years ago, and the United States must adapt its education programs to meet current needs (Friedman, 2005; Karoly & Panis, 2004; National Academy of Sciences, 2007; National Commission, 2000; NCREL, 2003

USDOL, 1991). Workforce reform is recommended at all education levels, from preschool to on-the-job training (Jacobs 2002; National Academy of Science, 2007).

Workforce Development and Current Skills

Human research development is a rapidly growing field of study. Considerable research is available on human research development theory and its role in workforce development (Swanson, 2001). With the current global economy, the best resource an organization, company, or nation has for a competitive advantage is its human capital, or talent (Elkeles & Phillips, 2007). Therefore, workforce development is the key to success in the modern economy. Jacobs (2002) describes it as the "coordination of public and private sector policies and programs that provides individuals with the opportunity for a sustainable livelihood and helps organizations achieve exemplary goals, consistent with the societal context" (p. 12). In order for the U.S. workforce to compete in the global economy, the country must have a well-trained workforce. This training extends through both public and private sectors and throughout a worker's life. To have the skills necessary to enter the workforce, elementary and secondary schools must start developing needed competencies (National Academy of Sciences, 2007; NCREL, 2003; P21, 2009a; Sturtevant, 2008; USDOL, 1991; Wagner, 2008).

To address workforce training, in 1990 the U.S. Department of Labor formed the Secretary's Commission of Achieving Necessary Skills (SCANS) to examine the demands of the current workforce, define the skills needed for employment, and determine if young people entering the workforce possessed those skills. "A SCANS Report for America 2000" was completed in 1991 and although over twenty years old, it is still relevant today. The report is regarded as seminal research in 21st century workforce development, and newer studies refer to SCANS when defining necessary skills for today's workforce (NCREL, 2003; P21, 2009a). The SCANS spent a year researching business needs by interviewing business owners, employers, managers, and workers. The Commission found that "good jobs depend on people who can put their knowledge to work. New workers must be creative and have the skills and attitudes on which employers can build" (USDOL, p. i). The SCANS discusses the effects of globalization and the resulting need for new skills such as adaptability and the ability to solve problems and work in teams. For the purposes of its report, the Commission limits the study and recommendations to one priority of education – the preparation of young people to enter the workforce. The SCANS study concentrates on the skills secondary students need for the global economy and does not include teacher education or skills outside of secondary school.

The report calls for the nation's schools to transform the education process and focus on new skills. SCANS notes two changes in the last 25 years that force changes in the nation's workforce: 1) globalization of commerce and industry, and 2) exponential growth of on-the-job technology. The SCANS also states that high school learning should be taught "in context, placing learning objectives within a real environment rather than insisting students first learn in the abstract what they will be expected to apply" (1991, p. viii). The SCANS reports a disconnect between what businesses need and what secondary students learn. This chasm led to the development of three foundational skills and five main competencies that SCANS determines as critical to workplace success in the global, technology-based market. The SCANS foundational skills and related competencies are summarized in Table 2.

Table 2

SCANS Competencies Needed to Meet Workplace Demands

Summary	
The U.S. Department of Labor commissioned SCANS to determine the demands of the workplace and if students could meet those demands. SCANS grouped the competencies into five groups. Although completed in 1991, the skills remain relevant today.	
Competencies	Definition
Resources	Time, Money, Materials and Facilities, Human Resources
Interpersonal	Participates as a Member of a Team, Teaches Others New Skills, Serves Clients/Customers, Exercises Leadership, Negotiates, Works with Diversity
Information	Acquires and Evaluates Information, Organizes and Maintains Information, Interprets and Communicates Information, Uses Computers to Process Information
Systems	Understands Systems, Monitors and Corrects Performance, Improves or Designs Systems
Technology	Selects Technology, Applies Technology to Task, Maintains and Troubleshoots Equipment

The three foundational skills include: 1) basic skills of reading, writing, mathematics, speaking, and listening; 2) thinking skills such as creative thinking, decision-making, problem-solving, and reasoning; and 3) personal qualities including responsibility, integrity, and self-management. Overlaying the foundational skills are five competencies or the ability to: 1) identify, organize, plan, and allocate resources; 2) exhibit interpersonal skills; 3) acquire and use information; 4) understand and apply complex inter-relationships; and 5) work with a variety of technologies. The SCANS report states that the competencies can be applied at all levels of employment and for many diverse jobs. The competencies represent the attributes an employer would like to see in all employees. By investigating the job market of the 21st century and compiling a set of necessary competencies, the SCANS report results lay the groundwork for future studies.

One study that followed the SCANS report and also researched workforce development was the "enGauge® 21st Century Skills: Literacy in the Digital Age." Funded by a grant from the U.S. Department of Education, the North Central Regional Educational Laboratory (NCREL) completed the enGauge® report in 2003. Referencing SCANS and economic studies, NRCEL provides an updated set of workplace skills needed for success in the digital age. "The current and future health of America's 21st century economy depends directly on how broadly and deeply Americans reach a new level of literacy – 21st Century literacy" (21st Century Workforce Commission, 2000, p. 13). The enGauge report discusses the influence of technology on the job market on school age children and cites the need for schools to change education delivery to accommodate technology. The report cites a discussion with Douglas Rushkoff, an American writer and media theorist, who states, "Children are native to cyberspace and we, as adults, are immigrants" (NRCEL, p. 4). Over 65% of children in the United States access the Internet regularly (NCREL, 2003). As a result of this rapid growth in technology and its use on the job, new workplace competencies are needed. The enGauge® report builds on the SCANS competencies and modernizes the skills to fit the digital age. Much like SCANS, enGauge® reports skill clusters broken down further into skill sets. The four skill clusters include: 1) digital-age literacy; 2) inventive thinking; 3) effective communication; and 4) high productivity (NRCEL, 2003). The competencies are shown in Table 3. The competencies were developed through a literature review, analysis of workforce trends, and surveys from educators and employers.

Table 3

enGauge® 21st Century Skills Needed for Workplace Success

Summary	
In a two-year study funded by the U.S. Department of Education, the North Central Regional Educational Laboratory and the Metiri Group studied workforce and technology trends to determine the competencies needed for success in the digital age. This report advocates new education paradigms for workforce skills and divides competencies into four areas of academic achievement. The SCANS report serves as a basis for this research.	
Competencies	**Definition**
Digital-Age Literacy	Basic, Scientific, Economic, and Technological Literacies; Visual and Information Literacies; Multicultural Literacy and Global Awareness
Effective Communication	Teaming, Collaboration, and Interpersonal Skills; Personal, Social, and Civic Responsibility, Interactive Communication
Inventive Thinking	Adaptability, Managing Complexity, and Self-Direction; Curiosity, Creativity, and Risk Taking; Higher-Order Thinking and Sound Reasoning
High Productivity	Prioritizing, Planning, And Managing for Results; Effective Use of real-World Tools; Ability to Produce Relevant, High-Quality Products

A breakdown of the four clusters includes basic literacy, scientific literacy, economic literacy, global awareness, adaptability, creativity, risk-taking, collaboration, civic responsibility, prioritizing, and an ability to produce relevant, high-quality products. All of the skills involve critical thinking – the ability to apply learned knowledge to create a desired outcome. Similar to SCANS, enGauge® pushes for school systems to change methodologies to teach workplace skills by shifting "from plateaus of knowing to continuous cycles of learning" (NRCEL, 2003, p. 11). Inquiry-based classrooms that immerse students in the application of theory are the way of the future (ITEEA, 2011; National Academy of Engineering, 2009; NCREL, 2003; USDOL, 1993, 1991). Teaching in context and through experimentation allows the student to learn, make connections, and develop the higher order thinking skills needed for success in the workforce.

In addition to the SCANS and enGauge® reports, a third study was conducted through Partnership for 21st Century Skills (P21), a national organization that advocates workforce skills for all students. The partnership began as collaboration between business and technical companies to recommend changes in education. The companies recognized a gap between what students were learning and what they needed to know for success in a global economy (Jacobs, 2010). The P21 developed a set of core skills emphasizing the "3Rs and 4Cs" (P21, 2006). The 3Rs of reading, writing, and arithmetic, serve as the basis for all student knowledge. The 4Cs take the learning a step further to include the skills of critical thinking, problem solving, communication, teamwork, and others. The P21 asserts the 3Rs and 4Cs are critical for today's workforce. “Are They Ready to Work?” a report published by P21 (2006), investigates the skills needed for the current workforce.

Table 4

Partnership for 21st Century’s Basic and Applied Workforce Skills

Summary	
P21 is a national organization that advocates workforce skills for all students and recommends students learn basic and applied skills for success in today’s economy.	
Basic Knowledge Skills	**Applied Skills**
English Language (spoken)	Critical Thinking/Problem Solving
Reading Comprehension (in English)	Oral Communications
Writing in English (grammar, spelling)	Written Communications
Mathematics	Teamwork/Collaboration
Science	Diversity
Government/Economics	Information Technology Application
Humanities/Arts	Leadership
Foreign Languages	Creativity/Innovation
History/Geography	Lifelong Learning/Self-Direction
	Professionalism
	Ethics/Social Responsibility

Note: This table was adapted from “Are They Really Ready to Work?” Partnership for 21st Century Skills, 2006. Adapted with permission, see Appendix A.

The research includes an in-depth study of the corporate perspective of the workforce readiness of new employees (P21, 2006). Survey data from over 400 employers and interview data from 12 senior executives focus on skills needed for graduates from high school, technical college, and four-year colleges to succeed in the workplace. The findings indicate “applied skills on all levels trump basic knowledge and skills” (P21, 2006, p. 9). While basic knowledge is necessary to facilitate use of applied skills, the ability to use applied skills enables workplace performance. Results of the study reveal applied skills include critical thinking, problem solving, communication, and teamwork. Both basic skills and applied skills are shown in Table 4.

The P21 study highlights eleven applied skills. Although nomenclature and grouping changes from the SCANS to the enGauge to the P21 studies, the skills are very similar and have remained the same since the seminal SCANS report, published in 1991. The P21 skills are: 1) critical thinking/problem solving; 2) oral communications; 3) written communications; 4) teamwork/collaboration; 5) diversity, 6) information technology application; 7) leadership; 8) creativity/innovation; 9) lifelong learning/self direction; 10) professionalism/work ethic; and 11) ethics/responsibility (p. 9). The P21 report also provides a framework for the applied skills as noted in Table 5.

Table 5

Partnership for 21st Century's Interdisciplinary Skills Needed for Workforce Success

Summary	
The Partnership for 21st Century Skills states today's student must master core subjects plus 21st Century interdisciplinary themes as listed below.	
Competencies	**Definition**
Learning and Innovation Skills	Think Creatively, Work Creatively with Others, Implement Solutions, Reason Effectively, Use Systems Thinking, Make Judgments and Decisions, Solve Problems, Communicate with Others, Collaborate with Others
Information, Media, and Technology Skills	Access and Evaluate Information, Use and Manage Information, Analyze Media, Create Media Products, Apply Technology Effectively

Table 5 (continued).

Competencies	Definition
Life and Career Skills	Adapt to Change, Be Flexible, Manage Goals and Time, Work Independently, Be Self-directed Learners, Interact Effectively with Others, Work Effectively in Diverse Teams, Manage Projects, Produce Results, Guide and Lead Others, Be Responsible to Others

State departments of education use workforce studies and research such as SCANS, enGauge®, and P21, to determine skills necessary for success in today's economy. As a result, the departments redefine primary and secondary frameworks to teach students new, applied skills. Jacobs (2010) defines sustainable education as the effort to "develop in young people and adults the knowledge, skills, attitudes, and enduring understandings required to individually and collectively contribute to a healthy and sustainable future" (p. 170). State departments of education are building a sustainable future by training students to be workers who can make complex decisions, solve problems, and communicate in the technical world (Wroten, 2008). Mississippi recognizes the importance of applied skills and emphasizes the competencies in the Department of Education's 2010 Science Framework purpose statement: "Instruction (in science) is designed to expose students to experiences which reflect how science should be valued, to enhance students' confidence to apply scientific processes, and to help students learn to reason and communicate scientifically" (Wroten, 2008, p. 8). The framework defines a curriculum with more emphasis on applying skills in context, working in groups, communicating science explanations, managing ideas and information, and publically communicating ideas to classmates. The Mississippi Science Framework utilizes spiral learning to provide for big picture ideas, to prevent gaps in knowledge, to teach developmentally appropriate content, and to scaffold and sequence understanding (Wroten, 2008).

Learning Theory

To teach applied skills for today's workforce, it is necessary to understand how students learn. In the 1960s, Benjamin Bloom created a taxonomy, or hierarchy of learning, dividing learning into six levels of increasing complexity (ASTD, 2006). The levels are knowledge, comprehension, application, analysis, synthesis, and evaluation. Each lower level must be mastered before moving to the next level. Similarly, P21 (2011) groups skills into three *ranges* or levels: 1) novice; 2) intermediate; and 3) advanced. The advanced range equates to Bloom's synthesis and evaluation levels. For grade school subjects like mathematics and science, mastery at each level is particularly important as concepts build on one another (Sturtevant, 2008). To facilitate learning at each level, educators must understand how students learn and apply knowledge (Mooney, 2000; Slavin, 1997; Vygotsky, 1978). In addition, understanding the roots of the current U.S. education system provides a background for understanding today's school curriculum.

In 1892, a Committee of Ten, as appointed by the National Education Association, decided all students in the U.S. should be taught the same curriculum, and it should occur over twelve years. Because the school calendar was based on an agricultural society, 180 days of instruction ensured three months off during the summer. Schools were not designed for children but were based on the model of an industrial factory (Jacobs, 2010). “This was not a developmental approach. It is noteworthy that famed developmental psychologist Jean Piaget was born in 1896, too late to redirect the committee’s notion of who children are and what they do to learn” (Jacobs, 2010, p. 9). The majority of the country’s schools follow this model today, despite enormous changes in technology and society.

Psychological and educational research date back over 100 years. The findings are valid today and are prerequisite for effectively teaching students today (Mooney, 2000). The best-known child psychologist of the century is Jean Piaget who lived from 1896-1980 (Slavin, 1997). Piaget’s concepts have shaped the American school system for the past thirty years (Mooney, 2000). Two of Piaget’s contributions to educational psychology or learning theory are constructivism and the theory of cognitive development. While many of Piaget’s contemporaries believe all learning is either intrinsic or extrinsic, Piaget asserts that neither is the case. His observations of children led him to believe that interaction with the environment creates learning (Mooney, 2000). Piaget postulates children *construct* their own reality or knowledge through interaction, i.e., children learn about their world through their own actions within that world (Mooney, 2000; Piaget, 1959; Tudge & Winterhoff, 1993). Piaget states, “construction is superior to instruction” (Mooney, 2000, p. 61). Learning is strengthened when children (and people in general) interact with surroundings rather than only listening to an instructor.

Piaget's view of learning and constructivism formed his theory of cognitive development. Basically, Piaget asserts all children are born with a desire to interact with and to understand their environment. Piaget also states that as children grow and interact with the world, they develop different schemes or methods for understanding their environment (Piaget 1959; Slavin, 1997). Piaget divides a child's growth into four stages of cognitive development, each stage dependent upon the former for abilities and behaviors to emerge (Mooney, 2000; Slavin, 1997; Tudge & Winterhoff, 1993). For the development of workforce skills, a person must reach the fourth and final of Piaget's stages, the formal operational stage. In this stage, which usually occurs around the age of eleven and older, students are able to think conceptually and abstractly. When a student reaches this stage, as noted by Piaget's observations, the student begins to use logic and can reason through hypothetical situations to solve problems (Slavin, 1997). Piaget believes that children logically progress through stages that enable more and more complex thinking through interaction with the environment. Classroom implementation of Piagetian theories includes activities that are open-ended, hands-on, and allow a student to learn through real-world experiences rather than lecture. This type of learning enables student interaction with the environment and supports cognitive development (Mooney, 2000). It also moves the student's development into synthesis and evaluation, the higher end of Bloom's taxonomy. The process of cognitive development is crucial for a student to grow into an adult who possesses the critical skills of problem-solving, critical thinking, and creativity.

Another seminal education psychologist, Lev Vygotsky, also believes that children learn through personal experience (Mooney, 2000; Tudge & Winterhoff, 1993; Vygotsky, 1986, 1978). However, where Piaget's work focuses on the internal processes of a child within the environment, Vygotsky asserts the child's understanding of the world is heavily influenced by the values and beliefs of others (Vygotsky, 1986, 1978). This interaction with adults and other children contributes to a child's learning or construction of knowledge. Vygotsky's main contribution to educational psychology is research on the importance of communication and interaction with others to increase a child's knowledge and cognitive skills (Mooney, 2000).

The cornerstone of Vygotsky's theory is the zone of proximal development, or the "place at which a child's empirically rich but disorganized spontaneous concepts 'meet' the systematicity and logic of adult reasoning" (Vygotsky, 1986, p. xxxv). Vygotsky describes the zone of proximal development as the distance between the hardest tasking a child can do alone (actual development level) and the hardest task the child can accomplish with the aid of an adult or peer (potential development level). Vygotsky believes a child on the verge of learning a new idea can be aided by someone more knowledgeable. The concept is often referred to as scaffolding (Slavin, 1997). Collaboration with an adult or peer is critical for this transfer of knowledge. In Vygotsky's view, a child can be led to understand higher concepts by being placed in situations where competence and skill level is stretched. The zone of proximal development emphasizes developmental readiness and learning through interaction (Mooney, 2000). Some researchers state that what a child can accomplish through scaffolding and social interaction is more indicative of his cognitive skills than what he can do alone (Vygotsky, 1978).

Vygotsky's theories of cognitive learning as a result of interactions with society, scaffolding, and the zone of proximal development are key concepts for mentoring and development of 21st century workforce skills. Critical thinking, problem solving, and other higher order skills can be learned through scaffolding. A student on the verge of understanding a complex problem or process can, with the aid of a mentor, reach a higher level or more in-depth understanding (Lave & Wenger, 1991). A mentor brings real-world experience to the student and can serve as the bridge between the conceptual or theoretical understanding learned in school and the application of the concepts. Often, the real-world experience mentors share with students is multidisciplinary and combines subject matters to solve a problem. Vygotsky's zone of proximal development is a key factor in education today as teachers provide *scaffolding* for students to learn new concepts. Scaffolding is also important in youth mentoring relationships as adult mentors can provide structure, challenges, and achievable goals to motivate a student (Larson, 2006). Through collaborative work and interchange of ideas, mentors can nurture students' ideas and help them extend their current knowledge and theories (Rhodes et al., 2006). Results from a science outreach study show that science mentors inspire students and help them better understand their own capabilities (MacDonald & Sherman, 2007).

MacDonald and Sherman (2007) researched mentor relationships formed during an after-school science activity at a local community center. In the study, six middle and high school students were paired with a professor who served as a mentor. Students and mentors participated in weekly sessions, and students were able to request mentor help on specific science topics. The study population was small, but all participants reported gains in self-confidence and problem solving. The most significant mentor trait identified was the mentors' ability to relate their knowledge to the students. By adapting content, timing, and delivery to individual students, the mentors were able to provide successful scaffolding experiences. As a whole, through collaboration with mentors, the students increased their science knowledge and confidence levels. MacDonald and Sherman's study enforces theories of learning as a social activity as advocated by Piaget and Vygotsky. The study provides further evidence for Vygotsky's zone of proximal development and Piaget's view of constructivism.

A protégé of Piaget, Seymour Papert, expanded the theory of constructivism to create a new theory of constructionism. As discussed earlier, in constructivism, the learner plays an active role in creating a reality based on experiences and beliefs. "Constructionism is unique in that it emphasizes 'learning by making" as the key aspect of the learning activity" (Williams, Ma, Prejean, Ford, & Lai, 2007, p. 202). Constructionism uses "objects to think with" to aid the learning process (Papert, 1993, p. 11). Where constructivism depends on a person's abstract reasoning, constructionism asserts that students use concrete methods for reaching higher levels of understanding (Sullivan & Moriarty, 2009). Papert's theory of constructionism expands on Paiget's theory of constructivism to include technology as part of the world within which students interact and learn.

Use of hands-on tools such as robots and computers enables students to create new ideas and learn experientially (Lindh & Holgersson, 2007). Papert was a strong proponent for technology in learning and in the 1960s, created LOGO, the first computer program for children. Papert chose the name LOGO to illustrate the program is a symbol-based language rather than numbers-based (Papert, 1993). For over twenty years, Papert used LOGO to research the benefits of technology for enriching learning experiences for elementary age children. Papert based LOGO on two ideas: 1) hands-on experience enriches learning and 2) the computer is an excellent medium to facilitate discovery learning (Lindh & Holgersson, 2007).

Papert advocates the robot as a perfect medium for technology learning because it is a concrete representation of the computer and its programs, i.e., the robot lends personality to the computer (Barker & Ansorge, 2007). Students relate to a robot more readily than to a computer. Instead of focusing on the computer and programming, students focus on the results of the programming demonstrated through the robot's actions. In Papert's research, the teacher or mentor guides technology learning and uses scaffolding to promote a student's understanding of the robotic operation. "Through use of hands-on experimentation, … technologies can help youth to translate abstract mathematics and science concepts into concrete real-world application" (Nugent, Baker, Grandgeneet, & Adamchuk, 2010, p. 392).

Since Papert's original study with LOGO and the use of technology to expand student learning, further research confirms the findings. In 2007, Barker and Ansorge conducted a study on the effectiveness of LEGO® robotics as a method to increase test scores in youth ages nine through eleven. The setting was an afterschool 4-H club with 32 students. The experimental group reported a significant increase in achievement scores post-intervention while the control group revealed no significant changes. In a similar study the same year, research indicates that participation in a summer robotics camp increased middle-school students' physics knowledge (Williams et al., 2007). Departing from the potential for technology to increase formal learning, Bers (2006) researched the potential for computers and robots to enhance positive youth development. Bers' exploratory study used computers and LEGO® robotics as the intervention. Families worked on the robotics activities together. Results revealed families felt more connected after completing the robotics activities, children were proud of their learning, and a caring, supportive learning environment was created. Piaget, Vygotsky, and Papert provide evidence-based research to support the importance of a student's interaction with the environment to increase in-depth learning. Their research into learning as a social science emphasizes the role of teachers, more knowledgeable adults, and technology in helping student's relate to the world around them to build a knowledge base and learn usable skills.

Mentoring

The SCANS report states that the "most effective way of learning skills is 'in context' placing learning objectives within a real environment rather than insisting that students learn in the abstract what they will be expected to apply" (USDOL, 1991, p. viii). Lave and Wenger's (1991) research on *situated learning* furthers the concept of applied learning. Instead of examining the cognitive processes of learning, Lave and

Wenger study the kinds of social interaction conducive to learning. Lave and Wenger state learning is highly interactive and skills are learned through “legitimate peripheral participation” (1991, p.14). This process compares to the mentor-apprentice relationship learned in trades where the apprentice learns by watching the expert and gradually assumes more duties. Legitimate peripheral participation is similar to Vyogtsky’s zone of proximal development in which novice learners are assisted by an expert (Lave & Wenger, 1991; Vygotsky, 1978). Lave and Wenger’s studies continue the theory of learning as a social activity and further the notion of scaffolding or a community of practice for learning skills. The idea of apprenticeships and learning skills through the aid of a mentor dates back thousands of years.

The basic definition of a mentor is a trusted counselor or guide (Merriam-Webster, 2012). Earlier research describes the older, more experienced mentor supporting and guiding the younger, less experienced mentee (Garvey, 2012) per a formal apprenticeship model. The definition of mentoring has expanded in recent times to include models reflecting mentoring of youth by a non-parental figure or role model. Rhodes et al. (2006) define mentoring as a supportive and caring relationship between a youth and a non-parental adult. A mentor can provide structure and guidance for a youth (Larson, 2006), similar to the process described in Vygotsky’s zone of proximal development. The structure and caring relationship can promote emotional, social, and intellectual growth (Dubois & Rhodes, 2006) if there is a strong connection and mutual respect and trust (Rhodes & Dubois, 2008).

The first instance of mentoring appears in Homer's Odyssey, and research on mentoring can be found in publication as early as the 1700s (Garvey, 2012; McDonald & Sherman, 2007). The historical works relate mentoring to cognitive and social development through experiential learning (Garvey, 2012). Apprenticeships traditionally serve as a form of training and education with examples of mentor/mentee relationships in ancient China, feudal Europe, and modern day United States. Lave and Wenger (1991) cite a current example of apprenticeship with the U.S. Navy quartermasters. A quartermaster has the crucial role of plotting the ship's position. Novice quartermasters take specialized courses before they deploy to a ship, but all training is on the job. Before being allowed to have any responsibility, the novice must apprentice under an experienced quartermaster. The mentor closely monitors the novice's activities for several months, gradually allowing the trainee more responsibility. The example illustrates a formal mentoring process with an apprenticeship role for the trainee.

Mentoring is a valuable tool for workplace learning, especially in technical disciplines (Green, Graybeal, & Madison, 2011; Hamilton & Hamilton, 2002; Marra & Pangborn, 2001). There is "evidence that students do not understand what professionals in technical and engineering fields actually do, nor do they have a good picture of the skills and competencies they will need to be successful" (Marra & Pangborn, 2001, p. 36). By working closely with a mentor, a college student or an employee can gain: 1) a firm foundation of relevant skills and knowledge; 2) appreciation for expertise; 3) confidence in abilities; 4) how to be responsible; and 5) an understanding that learning lasts a lifetime (Hamilton & Hamilton, 2002). A mentor is an important guide for an employee's career because the mentor determines work tasks, provides guidance and expertise, and evaluates employee performance (Liu, Xu, & Weitz, 2011).

In 1983, Kram conducted an in-depth analysis on mentoring and identified two main roles of a workplace mentor: 1) vocational or career coaching and 2) psycho-social or social support. Burke (1984), Noe (1988), and Scandura (1992) add role modeling as a third dimension of mentoring. Additional studies (Burke & McKeen, 1990; Dreher & Ash, 1990; Viator & Scandura, 1991) provide evidence that mentored workers feel more integrated into their organizations, have a higher performance, are more likely to be promoted, and are more satisfied with their jobs. Kram and Isabella (1985) note "the mentor offers role modeling, counseling, confirmation, and friendship, which help the young adult to develop a sense of professional identity and competence" (p. 111). A study by Lankau and Scandura (2002) investigated personal learning in mentoring relationships by conducting a survey of employees of a medium-sized hospital. Almost 53% of the respondents indicated they were mentored. Mentored employees reported significantly higher learning with respect to relationships than non-mentored employees. Additionally, role modeling by mentors improved employees' personal skill development.

As advocated by Jacobs (2002), workforce development is a societal concern where developing skills in youth is as important as in adults. The support of the mentor and role modeling can create positive effects and can contribute to increased cognitive and social development but must be youth-centered to be effective (Rhodes & Lowe, 2008). Youth mentoring is perceived to lend to positive growth, and, as a result, is becoming increasingly popular as a teaching mechanism.

> An estimated three million youth are in formal one-to-one mentoring relationships in the United States, and funding and growth imperatives continue to fuel program expansion. Even larger numbers of youth report experiencing mentoring relationships outside these types of programs with adults such as teachers, coaches, neighbors, and extended family. (Rhodes & Dubois, 2008, p. 254)

Formal one-to-one mentoring programs exist for youth. Perhaps the best-known mentoring group is Big Brothers Big Sisters. As a nationwide program, Big Brothers Big Sisters participates in an extensive evaluation of the effectiveness of its mentors, including a seminal study by Grossman and Tierney in 1998 (Dubois & Rhodes, 2006; Herrera, Grossman, Kauh, & McMaken, 2011; Rhodes & Lowe, 2008;). The national level study found that mentorship had a generally positive effect on youth and the duration of the relationship was proportional to the positive effect. The researchers conclude mentored youth were significantly less likely to get into trouble and had more confidence in their academic performance (Grossman & Tierney, 1998). In 2011, Herrera et al. conducted a random assignment impact study on the Big Brothers Big Sisters school-based mentoring program and concluded mentored students perform better academically. They also concluded fundamental changes in a youth's performance and attitude occur over time, possibly even longer than the eighteen months allowed in the study's methodology.

Similar studies were conducted on Across Ages, a drug prevention program that pairs elder mentors with students. A mentor spent at least four hours per week with a student for a year. Activities included tutoring, performing community service together, and spending time with the student. As documented in the research, mentored students had improved attitudes, missed less days of school, and were not as susceptible to drug use (Aseltine, Dupre, & Lamlein, 2000; LoSciuto, Rajala, Townsend, & Taylor, 1996). Based on the positive effects of mentoring research of the mid-1990s, including the Big Brother Big Sister and Across Ages studies, youth mentoring programs surged in popularity (Herrera et al., 2011).

As mentoring programs have increased, so has research on the subject (Bell, Blair, Crawford & Lederman, 2003; Karcher et al., 2006; MacDonald & Sherman, 2007; Rhodes & Dubois, 2008; Rhodes et al., 2006). Research indicates mentoring of youth provides positive results (Rhodes & Dubois, 2008). However, the prevailing opinion of the value of mentoring prevents critical evaluation, and more rigorous research should be focused on subject context, structure of relationship, and program goals (Karcher et al., 2006). Furthermore, Rhodes and Lowe (2008) urge for more uniform standards for evaluation of mentoring programs. With the exception of a few studies, including Grossman and Tierney (1998), research lacks the statistical power to detect the more subtle effects of mentoring. Findings have not been generalized to larger populations with any confidence (Dubois et al., 2006). A meta-analysis of 55 evaluations of the effects of youth mentoring programs concludes that mentoring can be an effective form of prevention and intervention, but is most effective when best practices are used (Dubois, Holloway, Valentine, & Cooper, 2002).

Recent research delves into the most effective ways to mentor youth for sustained positive growth. Because mentoring grows from a relationship between a youth and a non-parental adult, a strong connection based on trust and respect is necessary (Rhodes & Dubois, 2008). Furthermore, mentoring is more effective when the mentor adopts a youth-centered approach, where the relationship emphasizes the youth's needs and interests (Rhodes & Dubois, 2008; Rhodes & Lowe, 2008). Mentors must be engaged and be able to convey feelings of concern and acceptance while also providing challenges for the youth's psychological growth (Deutsch & Spencer, 2009). Timing of mentoring activities is important. After school mentoring provides a structured, productive activity for youth during a typically unsupervised time of day (Komosa-Hawkins, 2009). Another key factor in successful mentoring, is the ability of the mentor to model successful and relevant behaviors (Rhodes & Lowe, 2008). Examples include modeling skills necessary for job performance, interacting and communicating respectfully with peers, and refraining from undesirable actions. Other best practices include well-developed expectations, training, structure, and support for mentors. Karcher (2008) suggests an emphasis on quality of mentoring programs rather than number of mentors. Because most mentoring programs are volunteer-based, lack of program clarity can cause retention issues. Rhodes and Lowe (2008) suggest exploring "optimal strategies for balancing the needs of the children for intensity with the time constraints and interests of volunteers" (p. 14).

Recent mentor programs have deviated from the traditional one-on-one mentor approach and, instead, focus on group mentoring, subject specific mentoring, site-based mentoring, and e-mentoring (online or distance mentoring) (Dubois & Rhodes, 2006). Site-based mentoring refers to mentoring that occurs primarily at a specific site, such as a school or church. The programs account for about 45% of youth mentoring programs and are often organized by context or subject matter (Karcher et al., 2006). About 70% of the site-based programs occur in a school setting, accounting for a subset category called school-based mentoring (Karcher et al., 2006; Randolph & Johnson, 2008). School-based mentoring is becoming more popular because it provides academic subject help for struggling students, typically requires less time from the mentor, and is more structured due to its connection to a school (Komosa-Hawkins, 2009). Group mentoring, when one or more mentors work with a few youth at a time, is another nontraditional approach gaining popularity. Group mentoring is typically site-based and can provide unique advantages for school and community settings. Evidence exists showing this approach may be effective for improving peer interactions and for gaining trust (Karcher et al., 2006). E-mentoring, or online mentoring, is also growing in popularity and can be effective when subject specific expertise is needed (O'Neill & Polman, 2004). With the development of technology and increased use of the Internet, adults can serve as mentors to reach geographically dispersed students and to deliver specialized content (Karcher, 2008).

In some studies, the alternative forms of mentoring have proven effective in promoting higher order learning. Karcher's (2008) randomized evaluation of the effectiveness of school-based mentoring shows boys and girls reported higher social skills (such as cooperation) and greater self-esteem. A study of the effectiveness of online mentoring as a method of improving students' written science communication skills reveals students who correspond with mentors have a statistically significant improvement in scientific arguments (O'Neill & Polman, 2004). Another study documented the use of mentors in an after-school activity at a local community center. Although students described different levels of satisfaction with the mentoring process, all students reported gains in self-confidence and the ability to solve problems. Overall, the students report a deeper understanding of the scientific process with the help of mentors (MacDonald & Sherman, 2007).

A key characteristic in the success of a mentoring program is the youth's perception of the mentor. The majority of research focuses on the impact of mentoring and its effectiveness on youth performance or behavior. Less research on youth or student perception of mentoring exists. A few studies seeking the youth perspective note the following conclusions. Youth who feel closer to mentors tend to exhibit larger improvements in academic work and lower percentages of undesirable behavior such as skipping school (Wheeler, Keller, & Dubois, 2010). Furthermore, when interviewed, students consider a mentor's content knowledge and the use of the knowledge as important. The mentor's ability to relate content to the students and the mentor's ability to inspire and create enthusiasm are critical from the student perspective (MacDonald & Sherman, 2007). Another aspect of the mentor/mentee relationship is the opportunity for the student to participate in fun activities (Rhodes, 2005).

Rhodes and Dubois (2008) warn against assuming a program that connects adults to students is mentoring. The underlying foundation of mentoring requires a “caring adult-youth relationship” (p. 257). Karcher et al. (2006) do not argue the importance of a relationship, but recognize program goals play a role in the effectiveness of mentoring. Instrumental mentoring, where the primary goal is to learn a skill or engage in a task, differs from developmental mentoring, which focuses on the student’s personal development (Karcher et al., 2006). “In fact, instrumental mentoring may be more effective and appropriate for mentoring youth in particular contexts, such as the workplace” (p. 714). Instrumental mentoring may be school-based, online, group, or another style of mentoring. The focus, however, remains on a context or topic, not overall youth development. Instrumental mentoring is the method of choice for a not-for-profit, extracurricular activity for high school students called FIRST.

FIRST Robotics

For Inspiration and Recognition of Science and Technology (FIRST) is a worldwide, not-for-profit organization created by Dean Kamen for the purpose of “creating a world where science and technology are celebrated and where young people dream of becoming science and technology leaders” (U.S. FIRST, 2013c). Kamen, an inventor and entrepreneur, holds over 440 patents, many for innovative medical devices known for revolutionizing healthcare. The inventions include the wearable insulin pump, the home dialysis machine, advanced prosthetic limbs, and the Segway Human Transporter (Kemper, 2003; U.S. FIRST, 2013a). As an advocate for science and technology, Kamen endeavors to make the study of STEM skills as exciting to students as athletic sports (Kemper, 2003). His solution is FIRST, a robotics competition that teams corporate engineers with high school students to inspire young people to pursue careers in science and technology. The competition started with 28 New Hampshire high school teams in 1992 and has grown to around 2850 teams worldwide for the 2014 season (U.S. FIRST, 2013a).

Since its inception, FIRST has grown to include levels of robotics challenges for all school age children. FIRST actively applies the philosophy of John Dewey who states that children learn not by doing but by thinking about what they are doing (Bell et al., 2003). Junior FIRST LEGO® League (Jr.FLL™) is designed for children ages six through nine and introduces them to the basics of engineering and critical thinking through play with LEGO. The next step, for children ages nine to fourteen, is FIRST LEGO® League (FLL). In FLL, students complete a themed challenge each year and are judged on three aspects of the challenge: 1) teamwork; 2) research; and 3) a robotics competition. The robot is a LEGO® MINDSTORMS robot that is built from LEGO® parts, weighs about two pounds, and is programmed to operate autonomously. For students ages 14 to 18, FIRST offers its newest challenge, FIRST Tech Challenge (FTC). As with the other levels of FIRST, FTC involves a new robotics challenge each year. The robot for FTC is larger (about ten to twenty pounds) and involves a more comprehensive build, complete with gears, sensors, and programmable controllers. The FTC emphasizes the hands-on aspects of STEM learning (U.S. FIRST, 2011). The fourth, and most technical component of FIRST is the FIRST Robotics Competition (FRC).

In the FIRST Robotics Competition (FRC), high school teams have six weeks to design and build a robot to complete a challenge. The challenge is different every year and includes both autonomous and remote-controlled modes. With time and budget limitations, a new and specific task each year, and strict robot specifications, FRC is as "close to 'real-world' engineering as a student can get" (U.S. FIRST, 2013e). FIRST promotional materials and the FIRST website emphasize how much fun FIRST is for students. In studies, 99% percent of FIRST coaches surveyed agreed that the robotics competition is a fun activity for the students (Berry, 2005), and 95% of FIRST alumni rated their experience as good or excellent (Brandeis, 2005). However, the true purpose of FIRST is not to create a fun activity for students. As Kamen states:

> The robot is just a vehicle, just a tool. The skills you walk away with will give you careers for a lifetime … FIRST is really a way to show you what the world of science, technology, inventing, and problem solving is (Bascomb, 2011, p. 22)

FIRST states that the robotics challenge, while fun, provides an opportunity to apply the knowledge from the classroom and to learn workforce skills by creating and building the robot (U.S. FIRST, 2009).

This hands-on experimentation helps the students translate mathematics and science concepts into concrete applications (Nugent et al., 2010; Papert, 1993). The contextual application of FIRST Robotics builds a deeper understanding of technical concepts because the student is required to synthesize information and create a product. The experiential learning of FIRST provides the depth of understanding desired in high school curricula (Wroten, 2008). Typical FIRST students, when compared to students with similar backgrounds and achievements, are significantly more likely to go to college, twice as likely to major in science or engineering, and more likely to seek a post-graduate degree. Participants are also ten times as likely to have an internship or co-op job in their freshman year of college and are more likely to participate in community activities such as mentoring (Brandeis, 2005).

In addition to the opportunity for experiential learning, FIRST encourages and matches corporate engineers and scientists with high school teams. The FIRST program states a major difference between FRC and other robotics programs is the participation of mentors, who serve as professional role models for the students. "Mentors engage and inspire students in ways far beyond science and technology. They enable both students and adults to appreciate the value of sportsmanship (and) teamwork." (U.S. FIRST, 2013d). In 2010, FIRST reported over 212,000 participants, more than 90,000 adult mentors, coaches, and volunteers, and 5,817,340 hours donated by adult volunteers and mentors for the spectrum of FIRST programs (U.S. FIRST, 2010). Because most students and high school teachers do not have the background knowledge needed to build and operate a robot, mentors play a vital role in a team's success (U.S. FIRST, 2013d). Similarly to Vygotsky's (1978) zone of proximal development, mentors provide the connection between the facts and theories learned in school and practical applications. "The only effective way to learn to do science is by *doing* science, alongside a skilled and experienced practitioner who can provide on-the-job support, criticism, and advice" (Hodson, 1993).

FIRST provides a mentoring guide and a handbook for volunteers. Topics covered are best practices for mentors and include building trust and respect, facilitating independent thought through youth-centered activities, and facilitation of learning skills (U.S. FIRST, 2007). FIRST trademarked the term *gracious professionalism,* a key theme throughout FIRST for all participants, students, mentors, and volunteers. Dr. Woodie Flowers, FIRST National Advisor and Pappalardo Professor Emeritus Mechanical Engineering, Massachusetts Institute of Technology created the phrase to convey the importance of working within society to create and inspire.

> Gracious professionalism is part of the ethos of FIRST. It's a way of doing things that encourages high-quality work, emphasizes the value of others and respects individuals and the community … In the long run, gracious professionalism is part of pursuing a meaningful life. One can add to society and enjoy the satisfaction of knowing one has acted with integrity and sensitivity. (U.S. FIRST, 2013a)

For the past seventeen years, the highest honor an individual can receive from FIRST is the Woodie Flowers Award. The award is presented to a mentor who demonstrates excellence in empowering and inspiring students and who embodies gracious professionalism (U.S. FIRST, 2011). Research suggests that one of the key issues with mentoring is retention of volunteers. A difficult aspect of mentoring is retaining a volunteer's commitment for more than one year (Komosa-Hawkins, 2009). This is not the norm for FIRST mentors. Many teams have the same mentors for several years, lending to the ability to build relationships and program structure (Bascomb, 2011).

A 2005 survey of 175 FIRST coaches notes that 85% felt that one reason FIRST is fun for the students is because they have the opportunity to work with engineers. Notably, 79% of the coaches surveyed felt that volunteer mentors were the most important factor in student learning (Berry, 2005). In another survey, 95% of FIRST students surveyed state they were able to work closely with an adult, and 91% felt they learned a great deal from the adults (Brandeis, 2005). In the same survey, participants reported they had an increased understanding of the importance of teamwork (95%) and an increased understanding of the role of science and technology in daily life (89%). The FIRST participants also learned communication skills (95%), how to talk to people to obtain information (94%), how to solve unexpected problems (93%), how to manage time (90%), how to make informed decisions (94%), and how to gather and analyze information (88%) (Brandeis, 2005).

The FIRST program conducted two major program evaluations since its inception in 1992. The first evaluation, conducted by White Mountain Research Associates, monitored the long-term impact of FIRST and collected data from FIRST team leaders. The second evaluation, also measuring the impact of FIRST on participants and institutions, was conducted by the Brandeis University Center for Youth and Communities and was completed in 2005. In July of 2012, the FIRST program began a third evaluation that will follow 300-400 students over the course of five years and will compare the students to a control group not involved in FIRST. This study is conducted by the Center for Youth and Communities at the Heller School, Brandeis University. One of the key outcomes will include a measure of FIRST impact on the development of personal and workplace-related skills (U.S. FIRST, 2013c). Berry (2005) measures teacher perceptions of the educational value of FRC for workforce preparations in regard to STEM. Berry's survey data indicates coaches perceive students who participate in FIRST greatly improve workforce skills. Berry notes a need for further study of the FIRST programs on the influence of mentors on student motivation and learning of workforce skills. Similarly, in a review of research methods used to study youth mentoring, Dubois et al. (2006) note the scarcity of national studies on mentoring from a student.

Summary

With the current global economy, an organization's most critical resource for maintaining a competitive advantage is its personnel, and workforce development is a key factor in keeping the advantage (Elkeles & Phillips, 2007). All segments of society have a responsibility to provide workforce development, and this effort must begin in elementary and secondary schools (Jacobs, 2010; Jacobs, 2002). To address workforce training, the United Stated Department of Labor formed SCANS in 1991 to examine the demands of the current workforce, define the skills for employment, and determine if young people entering the workforce possess necessary skills. More studies, including the "enGuage® 21st Century Skills: Literacy in the Digital Age" report (2003) and Partnership for 21st Century Skills (2006, 2009a, 2009b) concur with the SCANS report and advocate for higher order, applied skills such as problem solving, critical thinking, teamwork, and communication.

Implementation of new curricula for learning workforce skills requires understanding how students learn (ASTD, 2006; Jacobs, 2010; Mooney, 2000). The research efforts of Piaget, Vygotsky, and Papert provide evidence on the importance of society, surroundings, and interaction with others for learning workforce skills. Mentoring high school students is one way to connect the facts and theories learned in school and their practical application (Vygotsky, 1978). Mentors can model successful and relevant behaviors necessary for job performance, including proper communication with peers, completing assignments on time, and solving problems (Rhodes & Lowe, 2008). One type of mentoring, instrumental mentoring, focuses on the development of a skill or task and is appropriate for teaching workplace skills (Karcher, 2008). A program that uses instrumental mentoring to enhance students' experiential learning is the FIRST program. The purpose of this study is to measure student perceptions of the effectiveness of mentoring on development of workforce skills, specifically, problem solving, critical thinking, teamwork, and communication. FIRST Robotics teams in Mississippi and Louisiana will serve as the population of the study. Methodology for measuring student perceptions of mentors' effectiveness is described in Chapter III.

CHAPTER III

METHODOLOGY

Introduction

Chapter III describes the methodology used to determine student perspectives of the effectiveness of mentoring for development of workforce skills. In today's global society, higher order skills such as problem solving, critical thinking, teamwork, and good communication are necessary for success in the workplace (National Academy of Sciences, 2007; P21, 2009; Sturtevant, 2008, USDOL, 1991). Educational studies over the past 100 years have shown that learning is a social activity (Mooney, 2000; Piaget, 1959; Vygotsky, 1978), and that mentors play a vital role in a student's understanding and learning of skills (Dubois & Rhodes, 2006; Lave & Wenger, 1991). Many afterschool programs provide mentoring opportunities for students. The FIRST program, an extracurricular activity, uses a robotics competition as a medium to teach about technology, engineering, and current workforce skills. Adult mentors provide the technical expertise necessary to build the robots. The FIRST Robotics Competition (FRC) notes the important role of mentors in providing guidance and necessary skills for robotics teams; however, data collected on mentors has been derived from team leaders or mentors themselves rather than the students (Brandeis, 2005). The purpose of this research is to determine the effectiveness of mentors in teaching workforce skills as measured by the perception of the student members of FIRST robotics teams.

The study seeks perception data from a student population and uses a mixed method approach. Mixed methods, employing both quantitative and qualitative research, is becoming a more commonly used research approach in the social sciences (Creswell, 2003). The mixed methods approach is appropriate for studies "that are products of the pragmatist paradigm and that combine the qualitative and quantitative approaches within different phases of the research process" (Terrell, 2012, p. 256). Mixed methods research is used to add to the richness of the research for a variety of purposes–to gain complementary views about the phenomena studied, to build a complete picture of the research, or to compensate for the weaknesses of one approach by using the other (Tashakkori & Teddlie, 2008). The researcher begins the study with a pragmatic approach where knowledge is based on actions, situations, and consequences. Pragmatism focuses on the problem rather than the method and uses multiple approaches to understand research results (Creswell, 2003). Data collected during the quantitative and qualitative phases of research provided information to determine the perceived effectiveness of mentors to develop four specific workforce skills. In the quantitative phase of the study, the researcher used a questionnaire to determine student perceptions of the effectiveness of team mentors. The qualitative phase used the results of the quantitative phase to further determine perceived effectiveness of mentors and provides more detailed information on findings.

Research Objectives

Based on the literature review, three research objectives were developed. The objectives were:

RO1: Describe FIRST students who participate on a robotics team by identifying team name and number, school name, perceived interest in STEM, number of years on a robotics team, and if mentored or non-mentored.

RO2: Determine FIRST student perceptions of the mentor's role in developing workforce skills, specifically: (a) problem solving, (b) critical thinking, (c) teamwork, and (d) communication.

RO3: Compare perceived differences between mentored and non-mentored FIRST student workforce skills, specifically: (a) problem solving, (b) critical thinking, (c) teamwork/ collaboration, and (d) communication.

Research Objective 1 used a questionnaire format to collect demographic data on participating students. Data collected included the school attended and team number, students' perceived interest in STEM, number of years active with a robotics team, future plans, and whether or not they worked with a mentor while on the team. Research Objective 2 determined students' perceptions of a mentor's role in developing four specific workforce skills. A questionnaire was used to determine student perception of their workforce skills and the perceived effect of mentor(s) on their workforce skill development for problem solving, critical thinking, teamwork, and communication. Once the data were analyzed, student focus groups were used to further inform the results. Research Objective 3 used a comparative test to distinguish the perceived difference in development of workforce skills for students who worked with mentors and those who did not. Inferential statistics were used to determine the perceived difference in workforce skills based on quantitative data collected.

Research Design

Creswell (2003) suggests a strategy for mixed methods research that includes four criteria: implementation, priority, integration, and theoretical perspective. Terrell (2012) further defines an implementation of sequential explanatory strategy and defines the steps as quantitative data collection, quantitative data analysis, qualitative data collection, qualitative data analysis, and interpretation. Figure 2 illustrates a version of Terrell's (2012) sequential explanatory strategy followed by the strategy as adapted to the present study. For Creswell's first criterion, implementation, the sequential explanatory process was used to determine the effectiveness of mentors as a method of developing four specific workforce skills. Quantitative data collection and analysis, or Phase 1, informed the direction for the qualitative portion of the study.

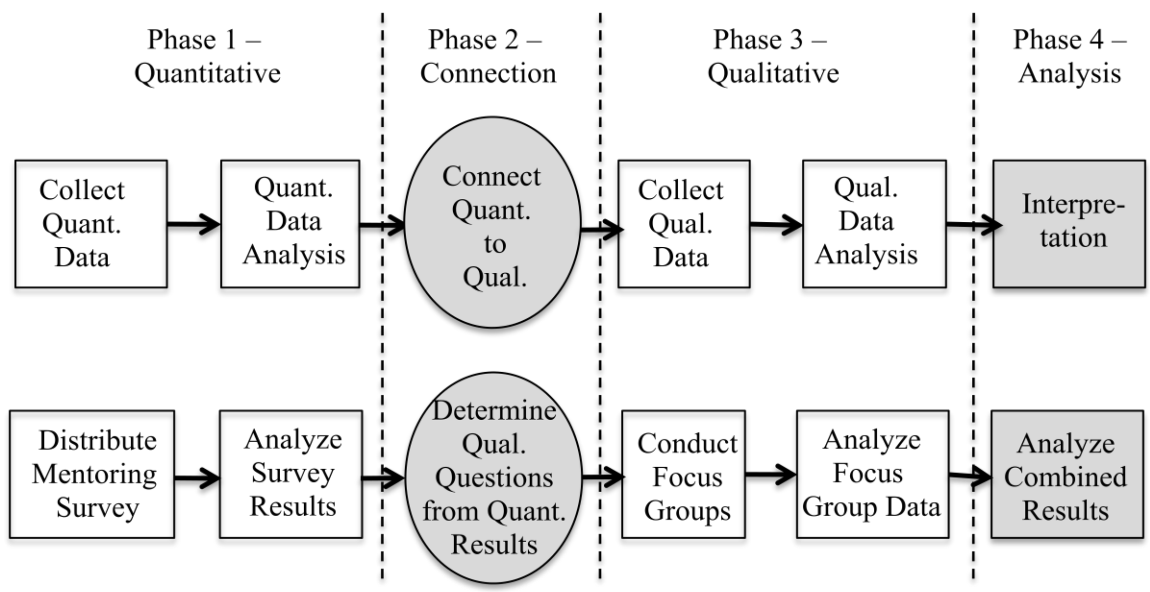

Figure 2. Representation of Terrell's sequential explanatory strategy and its application to the study of mentoring to improve four specific workforce skills. This mixed methods process uses quantitative data and analysis to inform qualitative data collection.

Creswell (2003) lists priority of approach as the second criterion in the research approach. Either the quantitative or qualitative approach may have priority in mixed methods research, or the priority can be equal. For the purposes of this study, quantitative research was given priority and was conducted first (Phase 1). In Phase 2 of the research, the statistics from the quantitative data were used to determine connections for the qualitative phase. The qualitative data were used to enrich the findings of the quantitative research in Phase 3. For Creswell's third criterion, the integration phase of the research, combination or mixing of data occurred, for the most part, at the data interpretation stage. A questionnaire was the source of quantitative data collection, and focus groups were used for the qualitative phase. For the fourth criterion and Phase 4 of the research, theoretical perspective, the researcher employed a pragmatic philosophy that used logic to combine methods and ideas (Johnson, Onwuegbuzie & Turner, 2007; Terrell, 2012).

Population

The FRC program includes 50,960 high school students from sixteen countries (U.S. FIRST, 2013b). A 2005 study on FIRST Robotics and its impact denotes a student population that is diverse, including a large number of women, minorities, and students from families with a limited education background (Brandeis, 2005). The distinguishing characteristic for the population of the present study included high school students (ninth through twelfth grades) who were participating on a FIRST Robotics team in either Mississippi or Louisiana during the time of the study. There were no other inclusion or exclusion criteria. Research on the participating Mississippi and Louisiana schools presented a diverse spread across academic and socioeconomic levels. Both public and private schools participated in FRC. Participating schools' average ACT scores ranged from 16.9 to 21.8, free and reduced lunch percentages ranged from close to 0% to 82%, and graduation rates varied from 56% to almost 100% (Kids Count Data Center, 2013).

In 2014, nine Mississippi FIRST Robotics teams and 31 Louisiana teams, with 828 students, participated in the program (C. Arthurs, personal communication, April 8, 2014). The number of team members was not published; therefore the researcher requested this information from the coaches and the FIRST Regional Director at the time of data collection. To determine the number of respondents needed for a meaningful study, the size of the sample is more important than the proportion of the population (Dillman, Smyth, & Christian, 2009). Calculation of the sample size was based on the following formula:

$$N_s = (N_p)(p)(1-P) / (N_p - 1)(B/C)^2 + (p)(1-p)$$

N_s is the sample size needed for desired precision, N_p is the population, p is the proportion of the population likely to choose one of two response categories, B is the margin of error, and C is the Z score associated with the confidence level (Dillman et al., 2009). For this study, the population totaled 828. The most conservative value for variance assumes that 50% of the population will answer "yes" and 50% will answer "no." This percentage is expressed as a decimal in the formula; therefore $p = .5$ (Dillman et al., 2009). Confidence level is most commonly set at 95%, reflecting that a random sample from the population will fall within the confidence interval 95 out of 100 times (Dillman et al., 2009; Walpole & Myers, 1993). Using a confidence level of 95% yielded a Z score of 1.96. Calculation per the formula resulted in a sample size (N_s) of 262.6, or 263.

Instrument

Surveys are the most familiar form of research in the social sciences and are used to describe the current characteristics of the population and to determine relationships within the sample (Graziano & Raulin, 2004). Surveys are a useful tool for studying people's behaviors and opinions. With a relatively small sample size, characteristics of a larger population can be estimated with confidence (Dillman et al., 2009). For the quantitative data collection portion of the study, the researcher designed a survey for high school students. A search for survey material yielded no single mentoring survey on participant perception; however, two survey instruments existed that asked questions applicable to the research. The first survey instrument used in part was the 2012 "FIRST® Team Member Survey" created by the Brandeis University Center for Youth and Communities as part of the current, ongoing longitudinal study of FIRST. With permission from FIRST and Brandeis (see Appendix B), parts of this survey were used to collect demographic data on students and to address the research topics of workforce skills development for problem solving, critical thinking, teamwork, and communication. In addition, a few questions from the "Critical Thinking in Everyday Life" survey for ages 12-18 developed by Mincemoyer, Perkins, and Munyua (2001), were used as a basis to create questions for the critical thinking portion of the research survey (permission received, see Appendix C). The final, researcher-developed survey collected nine demographic items and asked 41 additional questions to determine the effectiveness of mentors on four specific workforce skills as perceived by students on FIRST robotics teams. Table 6 maps the survey item number to the research objectives.

Table 6

Research Objectives / Survey Map

Research Objectives	Survey Item Number
R1 - Demographics	1, 2, 3, 4, 5, 6, 7, 8, 27, 28
R2A – Problem Solving, Mentor's Role in Development of Skill	11, 12, 13, 17, 25, 33, 34, 35, 39, 47
R2B – Critical Thinking, Mentor's Role in Development of Skill	16, 19, 20, 21, 22, 24, 26, 38, 41, 42, 43, 44, 46, 48
R2C – Teamwork, Mentor's Role in Development of Skill	8, 9, 10, 23, 30, 31, 32, 45
R2D - Communication, Mentor's Role in Development of Skill	14, 15, 18, 36, 37, 40
R3A – Problem Solving, Comparison of Mentored and Non-Mentored Students	11, 12, 13, 17, 25
R3B – Critical Thinking, Comparison of Mentored and Non-Mentored Students	16, 19, 20, 21, 22, 24, 26
R3C- Teamwork / Collaboration, Comparison of Mentored and Non-Mentored Students	8, 9, 10, 23
R3D – Communication, Comparison of Mentored and Non-Mentored Students	14, 15, 18

Note. Survey questions measure student perception of four workforce skills unassisted and with the help of a mentor. Mentored students completed the entire survey. Non-mentored students did not answer the questions about perception of workforce skills with the help of a mentor.

The survey created for data collection consisted of four sections. The first section included nine questions to collect demographical information: 1) team name; 2) team number; 3) school name; 4) years of participation in robotics; 5) primary reason for becoming involved with FIRST; 6) interest in STEM; 7) interest in technical jobs; 8) number of team mentors; and 9) number of mentors with whom the student worked. Sections 2 and 3 addressed each research objective with specific questions, as found in Table 6. Ten questions determined student perception of the effectiveness of a mentor in improving problem solving skills, 14 questions for critical thinking skills, eight for teamwork, and six for communications skills. All participants completed the demographical section, Section 1, of the survey. Section 2 of the survey, which asked the students to self-assess their workforce skills, was completed by all students. Section 3 questions gathered student perception of a mentor's effectiveness on workforce skill development. Students who did not work with a mentor were instructed to skip Section 3 questions. Additionally, Section 4 asked three open-ended questions to gain feedback and qualitative information from the mentored students. The complete survey instrument is located in Appendix D.

Data Collection

Data collection must be carefully planned to answer research objectives, and a data collection plan lays the groundwork for a study (Phillips & Skarwarski, 2008). The research used a sequential explanatory process with the quantitative research informing the qualitative phase. Table 7 details the research schedule, and Tables 8 and 10 provide overviews for the quantitative and qualitative plans, respectively.

Table 7

Data Collection Procedures and Planned Schedule

Item	Action	Schedule
1	Communicate and coordinate with robotics coaches (email, phone calls)	Weeks 1 - 3
2	Send permissions forms (mail to coaches)	Weeks 3 - 5
3	Receipt of permission forms	Week 6
4	Send questionnaire (mail to coaches)	Week 6
5	Coach holds meeting to administer surveys	Week 7
6	Send reminder	End of Week 7
7	Collect all surveys / End data collection	Week 8
8	Review data / Analyze results	Weeks 9 -10
9	Interpret quantitative data	Weeks 9 -10
10	Based on findings, develop questions for focus group(s)	Week 11
11	Coordinate with coaches to set up focus group meetings	Week 11
12	Organize and conduct focus group	Week 13
13	Collect data from focus group	Week 13
14	Interpret qualitative data	Weeks 14-15
15	Document findings	Week 16

The schedule was designed to occur within a FIRST Robotics calendar season to allow the researcher maximum access to the coaches and teams. The FRC season kickoff took place in early January. The robot build season was six weeks long, and the competition season lasted until the end of April. By collecting data during the January – April season, coaches were able to more easily administer the surveys, and students had current views and perceptions of the mentors' effectiveness on the development of workforce skills. The data collection and analysis effort (Phases 1-4) were scheduled to occur over a 16-week period. Phase 1, quantitative data collection, included communication with coaches, distribution and collection of permission forms, survey administration and collection, and data analysis. Phase 1 was scheduled for 10 weeks but took about 16 weeks to complete even though many reminders to participate were sent to the coaches. Phase 2, connection between quantitative and qualitative data, was planned for two weeks but took about six weeks. This phase included an exploration of the quantitative data and development of focus group questions based on the survey data. Once the qualitative data collection questions were formed, the researcher began Phase 3. The third phase included collection of qualitative data through a technology-enabled focus group and analysis of the data. Finally, in Phase 4, all data was compiled, synthesized, and interpreted for final results. Careful coordination with the coaches was necessary to collect data.

The researcher coordinated with Mississippi and Louisiana coaches and the FIRST Regional Director during the month of December to announce the study and seek participation. An incentive was offered to participating teams, as follows:

- Return of signed student and parent permission slips by deadline equaled one team entry for one of two $150 Home Depot gift cards.

- Over 50% student participation in survey by deadline equaled second team entry for one of two $150 Home Depot gift cards.
- Over 90% participation in student survey by deadline equaled third team entry for one of two $150 Home Depot gift cards.

Building and operating a robot is expensive and requires many tools and hardware such as drills, bolts, valves, and connectors. Registration fees are between $5000 and $6000 per event (U.S. FIRST, 2013e). As such, the chance to win a Home Depot gift card was a relevant and enticing incentive for the teams. Additionally, students who participated in the focus group had a chance to win individual prizes of one of two $50 Best Buy gift cards.

Every coach, participant, and parent/guardian was informed that participation in the study was voluntary and included completion of one student survey (about 20 minutes) and potentially a focus group (conducted by Adobe® Connect web conferencing for one hour). All surveys were anonymous and students were only tracked by the following demographics: 1) school name; 2) FRC team number; 3) number of team mentors; 4) primary reason for involvement with FIRST; 5) perceived interest in STEM subjects; and 6) perceived interest in STEM jobs.

Quantitative Phase of Study

The researcher submitted the study to The University of Southern Mississippi Institutional Review Board (IRB) to gain approval to conduct research on human subjects. The IRB application included several items: 1) detailed research procedures, 2) description of the population, 3) copy of the researcher-created survey, 4) research information letter for schools, parents and students, 5) oral presentation, 6) parent consent form, and 7) the student assent form. In addition, the researcher explained the procedure for gaining consent and the number, length of time, and location for each interaction with students. There were no known risks associated with student participation, but because the research involved children or potentially vulnerable subjects, extra forms, including school permission forms and parent permission forms, were required. The researcher also provided the IRB with documentation to show participation in the study was completely voluntary and students could decline participation with no adverse effects. After IRB approval was received, the researcher began the study. IRB approval is provided in Appendix E.

As part of the IRB, the researcher described the precautions taken to ensure safety of the physical and electronic data. After data were collected, all paper copies of permission forms, surveys, and focus group replies were stored in a locked filing cabinet inside a locked building. Digital data was stored on the researcher's password-protected computer inside a locked building. One year after the research is complete, paper documentation will be shredded. Digital data will be erased from all computer drives. The researcher is the only person with access to audio recordings, and they will be destroyed one year after the research is complete.

Because this research involved high school students, timing of data collection was critical. There was limited access to the students during the summer, requiring research to be completed during the school year. In addition, because the students were minors, both school and parental consent was necessary before any collection began. The first part of the data collection plan was to involve the stakeholders in the process (Phillips & Stawarski, 2008). The researcher contacted the robotics coach at each of the schools to explain the importance of the research and how it could help their FIRST teams. The researcher also engaged the FIRST Regional Director for Louisiana and Mississippi to help advertise the study. The invitation included a description of the incentive (drawing for $150 Home Depot gift cards) for participating teams. The coaches' invitation letter (sent via email) is provided in Appendix F. Each coach was asked to deliver an official letter to a school administrator, seeking school permission for students to complete the questionnaire and potentially participate in a focus group (Appendix G). When the school agreed to participate, the researcher mailed a package to the coach. The package included a checklist, permission forms for both the students and parents to sign, an oral presentation, the survey, and a code list to track unique survey numbers for selection of the focus group portion of the study. The parent letter and permission form is in Appendix H and the student permission form is in Appendix I. All letters described in detail: 1) purpose of the research; 2) risks; 3) benefits; 4) confidentiality; and 5) assurance of IRB approval. In addition to the written permission form, parents received a phone number to call for oral instructions. Before student survey administration, each coach provided an oral presentation for the students to clarify any questions or concerns. The oral presentation is provided in Appendix J. For the protection of minors and for participants to feel at ease answering questions, the surveys were anonymous (Phillips & Stawarski, 2008). Demographic data included details to inform the research, but they were not specific, in order to avoid identification of students.

Table 8

Quantitative Data Collection Plan

Research Objective	Broad Program Objectives	Measure	Data Collection Methods and Instruments	Data Sources
R1	Describe population of Mississippi and Louisiana FRC students	Open-ended questions, close-ended questions, 5-point unipolar scale, 7-point unipolar scale	Variation of FIRST Team Member Survey (Brandeis, 2012)	FRC Team members in Mississippi and Louisiana
R2	Determine perceived effectiveness of mentoring on development of workforce skills in four areas	4-point unipolar scale, open-ended questions	Questions from FIRST Team Member Survey (Brandeis, 2012) and Critical Thinking Survey (Mincemoyer, et. al, 2001)	FRC Team members in Mississippi and Louisiana
R3	Compare perceived difference in workforce skills between mentored and non-mentored students	4-point unipolar scale, open-ended questions	Questions from FIRST Team Member Survey (Brandeis, 2012) and Critical Thinking Survey (Mincemoyer, et. al, 2001)	FRC Team members in Mississippi and Louisiana

Note: Quantitative Data Collection Plan, Adapted from Phillips & Stawarski (2008), Data Collection Plan

Dillman et al. (2009) describe the importance of population coverage in survey research. Coverage error can result from every person in the survey population not having a known chance of inclusion. Survey administration is also important (Dillman et al., 2009; Phillips & Stawarski, 2008). The researcher could not assume that all students had access to a computer or the Internet, therefore electronic surveys were not used. One concern was that, with the age of the participants, self-administered surveys might not provide uniform results. To increase reliability, validity, and coverage, the researcher asked the coaches to administer the surveys per a described method — by holding a meeting after school to describe the purpose of the survey, distributing paper copies of the survey, and asking students to complete the surveys and return them prior to leaving the meeting. Only students with signed consent from parents were invited to attend the meeting. The coaches mailed the completed permission forms and surveys back to the researcher.

Qualitative Phase of Study

For the qualitative portion or Phase 3 of the research, the researcher conducted a semi-structured interview with a focus group of FRC students. The interview and questions were developed from the analysis of the quantitative phase of the study. Focus groups allow a researcher "to elicit opinions, attitudes, and beliefs" held by participants (Myers, 2009, p. 125). In focus groups, participants build on others' ideas, engage in thoughtful discussion, and typically generate rich data (Myers, 2009). Focus groups also provide more in-depth feedback and provide more specific information on questionnaire results. For proper data collection, a focus group should represent the target population (Phillips & Stawarski, 2008). For the FRC study, the focus group included only mentored students and was representative of the sample. Myers (2009) and Phillips and

Stawarski (2008) suggest the ideal size for a focus group is 7 - 12 people to generate discussion and allow participants time to express their views. This guidance was followed for the focus group planning. Each survey had a unique number code to facilitate random selection of focus group participants. To ensure both states were represented, the researcher drew four Mississippi team numbers and four Louisiana team numbers from a bag. After teams from each state were selected, the researcher randomly drew code numbers and sent a code number and two alternates to the coach for focus group participation. Names of students who did not have parent permission to participate in the focus group were also sent to the coaches and were removed from consideration. The coach kept a list that correlated the code to student name. The researcher did not have access to the list. Once the focus group was selected, the coach shredded the code list.

A local FIRST celebrity and mentor, Mr. Chris Copelan, served as the facilitator for the focus group. Mr. Copelan's participation provided a known adult for the students and allowed the researcher to listen to the conversation and take notes. A semi-structured interview was used to guide the focus group discussion, but the facilitator was encouraged to pursue new questions that naturally arose from the discussion (Doody & Noonan, 2013; Myers, 2009). The researcher followed the protocol for the interview development, to include: 1) asking as few questions as possible; 2) allowing the participants to do a majority of the discussion; 3) asking open-ended questions for rich discussion; 4) covering important topics as developed in Phase 1; and 5) not judging participant comments (Government of Quebec, 2009). Harrell and Bradley (2009) suggest a focus group protocol that includes a sequence of events, definition of a purpose, and a schedule. A sample format for the focus group is detailed in Table 9.

Table 9

Format for Semi-Structured Interview with Focus Group

Sequence	Purpose	Timing
Welcome and Introductions	Create an open atmosphere, allow participants to become comfortable in setting	4 minutes
Purpose and Ground Rules	Provide details on purpose of focus group, reminder of informed consent and confidentiality	4 minutes
Group Discussion – Problem Solving	Question for group’s input, based on results and phenomena from quantitative phase of study (Phase 1)	12 minutes
Group Discussion – Critical Thinking	Question for group’s input, based on results and phenomena from quantitative phase of study (Phase 1)	12 minutes
Group Discussion – Teamwork	Question for group’s input, based on results and phenomena from quantitative phase of study (Phase 1)	12 minutes
Group Discussion – Communications	Question for group’s input, based on results and phenomena from quantitative phase of study (Phase 1)	12 minutes
Final Thoughts and Closing	Bring closure to discussion, Collect final thoughts, Thank participants for participation	4 minutes

Due to the large geographical area of the schools and the added complexity and expense of arranging minors’ travel, the focus group was conducted through Adobe® Connect web conferencing. The students’ coaches were present during the focus group but did not participate. Adobe® Connect was used for the technology-enabled focus group because it was readily available to the researcher and did not require special software for participants. In addition, Adobe® Connect could easily handle the 7-12 connections necessary for the focus group, provided a video link for presentation, and allowed the researcher to audio record the session and store it securely on a computer. The presentation given to the students during the focus group is in Appendix K. Table 10 summarizes the qualitative data collection plan.

Table 10

Qualitative Data Collection Plan

Research Objective	Broad Program Objectives	Measure	Data Collection Methods and Instruments	Data Sources
R2	Determine perceived effectiveness of mentoring on development of skills in four areas of workforce development	Verbal feedback, answers to open-ended questions in questionnaire	Focus groups with semi-structured interviews	Subset of students who participated in the questionnaire
R3	Compare perceived difference in workforce skills between mentored and non-mentored students	Verbal feedback, answers to open-ended questions in questionnaire	Focus groups with semi-structured interviews	Subset of students who participated in the questionnaire

Note: Qualitative Data Collection Plan, Adapted from Phillips & Stawarski (2008), Data Collection Plan

The data resulting from answers to the focus group questions and to the open-ended survey questions were analyzed through a three step coding process as described by Myers (2009). “A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data” (Saldana, 2013, p. 3). The process of coding allowed the researcher to analyze data in an orderly manner to find information and develop concepts and theories to explain research phenomena (Chenail, 2012). The first phase of coding, or open coding, grouped the oral responses into categories. The second phase, axial or selective coding, interpreted the properties and categories of the responses for sub-themes to help with further analysis. The third and final stage, theoretical coding, developed themes or predictive statements about the phenomenon, i.e., the coding was used to formulate a theory. NVivo software was used to organize and analyze the qualitative data. The results described student perceptions of effectiveness of a mentor on workforce skills.

Validity and Reliability

The researcher-developed survey is the basis for the analysis of student perceptions of the effectiveness of a mentor on four specific workforce skills. As such, the validity of the survey and the resulting focus group questions affect the research. Validity and reliability must be addressed when conducting research (Creswell, 2003; Graziano & Raulin, 2004; Zohrabi, 2013).

Validity of Instrument

Content validity refers to how accurately the instrument measures the various aspects of the social construct or phenomena being studied (Huck, 2008). The current study seeks to measure student perceptions of the effectiveness of a mentor on the development of four workforce skills. For content validity, the survey items should adequately measure the student's perception of mentor effectiveness, and survey items should match specific workforce skills. The survey developed for this research is the combination of two published instruments. The survey for FIRST Robotics was developed by the Center for Youth and Communities at Heller School, Brandeis University to evaluate the impact of robotics on students' interests, activities, and career plans and goals (Brandeis, 2012). A section of the survey is used to determine student perceptions of their workforce skills for problem solving, teamwork, and communication. Questions from a second survey, "Critical Thinking in Everyday Life" by Mincemoyer et al. (2001), were adapted to complete the fourth workforce skill of critical thinking. The authors based their survey on Lerner's 5-C's, an established and widely accepted model for measuring skills. The Brandeis survey and the Mincemoyer et al. survey were combined for the current research. To ensure content validity, the resulting survey was reviewed for clarity and correlation to research objectives by two subject matter experts: 1) a FIRST partner with considerable robotics and STEM workforce skills experience and 2) an educator with STEM evaluation expertise.

In addition to content validity, the subject matter experts reviewed the survey for face validity. If the survey appears to measure what it should and the instructions and questions use a language the participants can understand, it is said to have face validity (Humphrey et al., 2013). To ensure the survey language, content, and layout was understood by participants, an additional reviewer was added. The third reviewer, who reviewed for face validity only, was a representative user — a high school student with experience in FIRST programs. This person did not participate in the study.

Internal Validity

Internal validity answers the question, "Was the independent variable, and not some extraneous variable, responsible for the observed changes in the dependent variable?" (Graziano & Raulin, 2004, p. 183). To maintain internal validity, the change to the dependent variable should be caused by the independent variable. For the current research, students are the dependent variable and mentor support is the independent variable.

Internal validity can be threatened by many variables including inadequate procedures, history, design contamination, maturation, or mortality (Creswell, 2003; Michael, 2002). To maintain internal validity through the procedure, the survey was administered in the same way by each coach. In addition, the survey included both closed-ended and open-ended questions to obtain information in different ways (Myers, 2009). Further, the focus group questions delved into the information provided by the survey. The combination of survey and focus group allowed the researcher to collect data in two different ways to strengthen internal validity (Myers, 2009; Zohrabi, 2013). History is defined as an unanticipated event that may occur while the research is in progress. Possible uncontrollable events could include the loss of a mentor during the season or an unexpected performance at a competition. To avoid this possibility, the researcher monitored the competition schedule and results. Another threat to internal validity is design contamination. One method of contamination occurs when one group discusses the study with another group (Creswell, 2003). This was not an issue due to the geographic separation of the teams. Design contamination can also result when a participant seeks to make the research succeed or fail (Michael, 2002). Because the participants are teenagers, the possibility exists that some participants completed the survey in jest. The researcher looked for outliers during data analysis. Maturation is another threat to internal validity (Creswell, 2003). The projected research time of four months was not long enough for notable subject change in participant maturity.

External Validity

External validity addresses how well the study can be generalized to other populations or settings (Graziano & Raulin, 2004). Threats to external validity can occur when the researcher incorrectly assumes or infers that data from the sample can be applied to other subjects. Sample size and population representation are other threats to external validity (Graziano & Raul, 2004). The research on student perception of mentor effectiveness on four specific workforce skills includes a population limited to FRC teams, specifically in Louisiana and Mississippi. Further distribution of the survey would be required to generalize results to a population larger than the study group.

Reliability

In addition to validity, other qualities, including reliability, consistency, and repeatability of the research result, are important (Zohrabi, 2013). Reliability of measures “is critical in research because, if the measures are not reliable, the study cannot produce useful information” (Graziano & Raul, 2004, p. 89). The FIRST study designed by Brandeis has a Chronbach’s alpha of .88 for the workforce skills section of its survey (Melchior, personal communication, October 3, 2014). Mincemoyer, Perkins, and Munyoa (2001) list an internal consistency of 0.72 for the “Critical Thinking in Everyday Life” survey.

Summary

The described research uses a mixed methods approach to determine students’ perceptions of the effectiveness of mentors on the development of four specific workforce skills. The population includes FIRST Robotics students from teams in Mississippi and Louisiana. The study follows a pragmatic approach and implements a sequential explanatory strategy for the findings of the quantitative data to inform the qualitative phase of the study. The quantitative phase uses survey data to describe and measure student perception of the effectiveness of mentors in the development of workforce skills. Based on survey responses, the researcher used focus group questions and open-ended survey questions to further explore findings and phenomena.

CHAPTER IV

ANALYSIS OF DATA

The purpose of this study is to use student perceptions to determine the effectiveness of mentoring as a method for the development of four specific workforce skills in high school students. The study combines literature review of current workforce skills, foundational theories of education, and recent research of the effectiveness of mentors and types of mentoring. Educational research indicates learning occurs through interaction with the environment and others. Studies show that mentoring can be an effective method of workforce development when the delivery meets the needs of the participant and is student-centered (Rhodes & Dubois, 2008; Rhodes & Lowe, 2008). Using the FIRST Robotics students as a population, the researcher has collected student perception data. The description of and results from the data analysis are presented in this chapter, following the sequential explanatory method explained in Chapter III (Terrell, 2012). Analysis begins with quantitative data and concludes with qualitative.

Data Collection

The population for this study included 828 FIRST robotics students on 40 Mississippi and Louisiana teams in 2014. Louisiana has roughly three times as many teams and students as Mississippi with 31 teams and 620 students. Mississippi teams totaled nine with 208 students. Despite the difference in team and student numbers, survey participation was almost equal with 148 surveys completed by Mississippi teams and 146 by Louisiana teams for a total of 294. The higher return rate in Mississippi was in part due to two large teams completing the surveys (87 surveys between the two teams). Although more Louisiana teams participated, the teams were smaller or a lower percentage of students completed the survey. Participation is shown in Table 11.

Table 11

Survey Participation for Student Perceptions of Mentoring to Develop Workforce Skills

Overall Participation					
	Total Teams	Population	Number of Teams	Number of Participants	Percentage of Surveys Completed
Mississippi	9	208	6	148	71.1
Louisiana	31	620	9	146	23.6
Total	40	828	15	294	35.5

Of the 294 student participants, 277 (94.2%) worked with a mentor. Only 17 (5.8%) stated they did not work with a mentor. Of the 17, six were on one team that did not have a team mentor. The other 11 worked on teams with mentors but did not work directly with a mentor either through choice or because the team did not have a mentor that specialized in their subject area. Table 12 includes statistics for mentored and non-mentored students.

Table 12

Mentored and Non-Mentored Student Sample

Survey Participants	Number of Participants	Percentage of Participants
Students who worked with a mentor	277	94.2
Students who did not work with a mentor	17	5.8

Limitations of Data Collection

Thirty-five percent of the population completed the survey instrument. The 294 participants were above the 263 needed for a confidence level of 95%. Fifteen of the 40 Mississippi and Louisiana teams participated in the research. Of the 25 teams that did not participate, four agreed to be involved but did not complete surveys despite several requests. Two teams declined to participate, and the remaining 19 were nonresponsive. One team participated in the survey phase but stated it could not participate in the focus group due to school regulations that prohibited recording of students. On multiple teams, some parents gave permission for their children to complete the survey but did not allow them to participate in the focus group.

Quantitative Data Analysis

The quantitative data analysis is divided into three major sections, one for each research objective, and is based on survey completion.

Research Objective 1 – Describe Students Who Participate on a Robotics Team

The purpose of Research Objective 1 described FIRST students who participated on a robotics team by identifying team name and number, school name, perceived interest in STEM, number of years on a robotics team, and if mentored or non-mentored. The survey questions for the demographical section were used, with permission, from the ongoing, longitudinal Brandeis study of FIRST participants. The same questions were used to increase the body of knowledge, and to provide information for both the researcher's study and the Brandeis study. Of the participants surveyed, 46.2% (n = 136) were first year robotics team members, 29.3% (n = 86) had participated for two years, 14.6% (*n* = 43) participated for three years, and 9.2% (*n* = 27) reported more than three years of experience. Table 13 summarizes students' years of robotics experience.

Table 13

Years of Participation in FIRST Robotics

Number of Years	Students (*n* = 294)	Percentage of Students
1 year	136	46.2
2 years	86	29.3
3 years	43	14.6
More than 3	27	9.2

The participants were asked to select reason(s) for participation in robotics and allowed to select all reasons that applied. A large majority, 78.2% (*n* = 230), stated they were interested in STEM. Further breakdown of the STEM subjects showed 74.5% (*n* = 219) were interested in science, 80.0% (*n* = 235) in technology, 75.2% (*n* = 221) in engineering, and 67.0% (*n* = 197) in mathematics. Interest in STEM fields is documented in Table 14.

Table 14

Student Interest in STEM Fields as a Percentage (Number in Parentheses)

STEM Field	Not Interested								Very Interested	
Science	1.7	(5)	5.4	(16)	17.4	(51)	28.2	(83)	46.3	(136)
Technology	1.4	(4)	4.1	(12)	14.3	(42)	25.9	(76)	54.1	(159)
Engineering	3.4	(10)	6.5	(19)	15.0	(44)	25.5	(75)	49.7	(146)
Math	7.1	(5)	10.2	(30)	14.0	(41)	25.2	(74)	41.8	(123)

Note: *n* = 294. The survey scale included a 5-point range from "Not Interested" to "Very Interested."

Most participants also thought that robotics either "sounded cool" (73.5%, *n* = 216) or "looked fun" (70.1%, *n* = 206). Almost half (46.6%, *n* = 137) joined the robotics program because “they had friends on the team.” Very few chose to participate in robotics because it was “part of a class or program”, with just 8.2% (*n* = 24) and 3.1% (*n* = 9) respectively. Of interest for this research, 23.8% (*n* = 70), or almost one fourth of the students, participated because “a coach or mentor asked them.” Reasons for participation in robotics are detailed in Table 15.

Table 15

Reason for Student Participation in FIRST Robotics

Reason	Students (*n* = 294)	Percentage of Students
Interest in STEM	230	78.2
Sounded cool	86	73.5
Like to build	43	55.4
Help for college	27	45.6
Part of a class	24	8.2
Part of a program	9	3.1
Friend on team	137	46.6
Looked fun	206	70.1
Parent encouragement	72	24.5
Coach /Mentor request	70	23.8
Previous involvement	50	17.0
Other	22	7.5

The majority of survey participants were interested in becoming an engineer (64.0%, *n* = 188) or an inventor (52.1%, *n* = 153). Table 16 summarizes student interest in STEM jobs.

Table 16

Student Interest in STEM Jobs (Number in Parentheses)

STEM Job	Not Interested								Very Interested	
Scientist	10.2	(30)	12.9	(38)	27.9	(82)	27.2	(80)	20.4	(60)
Engineer	7.5	22)	8.8	(26)	20.0	(59)	21.8	(64)	42.2	(124)
Mathematician	26.2	(77)	15.7	(46)	26.5	(78)	20.8	(61)	10.5	(31)
Tech Specialist	9.9%	(29)	14.6	(48)	25.2	(74)	23.8	(70)	23.5	(69)
STEM Teacher	30.3	(89)	29.9	(88)	22.1	(65)	10.5	(31)	5.4%	(16)
Inventor	8.8%	(26)	13.3	(39)	23.8	(70)	26.2	(77)	25.9	(76)
Technician	11.9	(35)	18.4	(54)	29.6	(87)	22.8	(67)	14.0	(41)
Other	9.5	(28)	4.4	(13)	20.8	(61)	10.5	(31)	25.2	(74)

Note: *n* = 294. The survey scale included a 5-point range from "Not Interested" to "Very Interested."

Research Objective 2 – Student Perceptions of a Mentor's Role in Developing Workforce Skills

Research Objective 2 determined student perceptions of the mentor role in developing workforce skills, specifically: (a) problem solving, (b) critical thinking, (c) teamwork, and (d) communication. Frequency distribution was used to record and understand characteristics of the measurements (Huck, 2008) – specifically student perceptions of four workforce skills with and without the assistance of a mentor. Measures of central tendency, including mean and standard deviation, were determined. The researcher used the SPSS predictive analytics software for inferential statistical calculations to determine the differences between students' perceptions of their workforce skills with and without the assistance of a mentor.

Each of the four workforce skills was analyzed separately to determine if mentor assistance was perceived to be effective. Only data from the 277 students who indicated a current FIRST Robotics relationship with a mentor was used for Research Objective 2.

The survey used a four-point Likert scale to ask students their perceptions of how well they could perform a specific task that linked back to the four workforce skills. For example, one survey question under the teamwork skill asked, "How well can you work as part of a team on a project?" The Likert scale ranged from the lowest choice of "Not at All" to "A Little" and "Pretty Well," and ended with the highest choice of "Very Well." This scale was based on the existing FIRST Robotics survey instrument developed by the Brandeis University Center (2012). The number of points used in Likert scales can vary, with most scales using 4 to 7 points. Research suggests that 4 points is optimal and more than 7 points can affect reliability (Leung, 2011). As individual items, each survey question is considered Likert-type data. Likert-type items are defined as "single questions that use some aspect of the original Likert response alternatives" (Boone & Boone, 2012, p.2). Likert-type data is non-parametric and should be analyzed on an ordinal scale that determines proportion (Pell, 2005). A Likert scale, on the other hand, consists of a set of Likert-type items that are combined into a single value for analysis (Boone & Boone, 2012; Carifio & Perla, 2008). Likert-scale data can be analyzed at an interval scale using descriptive statistic techniques such as mean, standard deviation, and *t* tests (Boone & Boone, 2012). Analysis of interval scale data through parametric tests is more powerful and easier to interpret (Leung, 2011; Pell, 2005). For this reason, the questions for each of the four workforce skills were assigned a value and added to create a composite score. The response "Not at All" was given a value of 0, "A Little" was given a value of 1, "Pretty Well" had a value of 2, and "Very Well" a value of 3. This made the value of each Likert point or category across all the questions similar in weight, and created a ratio (Bond & Fox, 2012). Creating a ratio scale allowed the data to be considered interval data and provided more powerful analysis. This method was used to determine mean, standard deviation, and significance of difference between students' workforce skills when unassisted and with the help of a mentor.

Survey questions 8 through 26 asked students to measure their perceived ability in the four specific workforce skills on their own or unassisted. Questions 30 through 48 asked students to measure their perceived ability of the same four workforce skills as the result of working with a mentor or assisted. Mentored students answered both sets of questions. Non-mentored students only completed the first set of questions (8 through 26). Overall, students perceived their workforce skills of problem solving, critical thinking, teamwork, and communication increased with the assistance of a mentor. Both percentage and statistical mean were calculated for the set of questions associated with each workforce skill. When asked about how well they could apply the problem solving skill unassisted, students rated themselves as applying the skill "a little" (18.1%, M = 50.1), "pretty well" (50.8%, M = 140.7), and "very well" (29.6%, M = 82.0). With the help of a mentor, the students' perceptions of application of their skills changed to "pretty well" (34.2%, M = 94.7) and "very well" (60.5%, M = 167.6). The data show that the responses shifted in a positive direction, i.e., students perceived that their skills increased with the help of a mentor. This positive change was noted in all four of the workforce skills analyzed: problem solving, critical thinking, teamwork, and communication. The change in response of student perception from unassisted to mentor assistance for problem solving is illustrated in Figure 3.

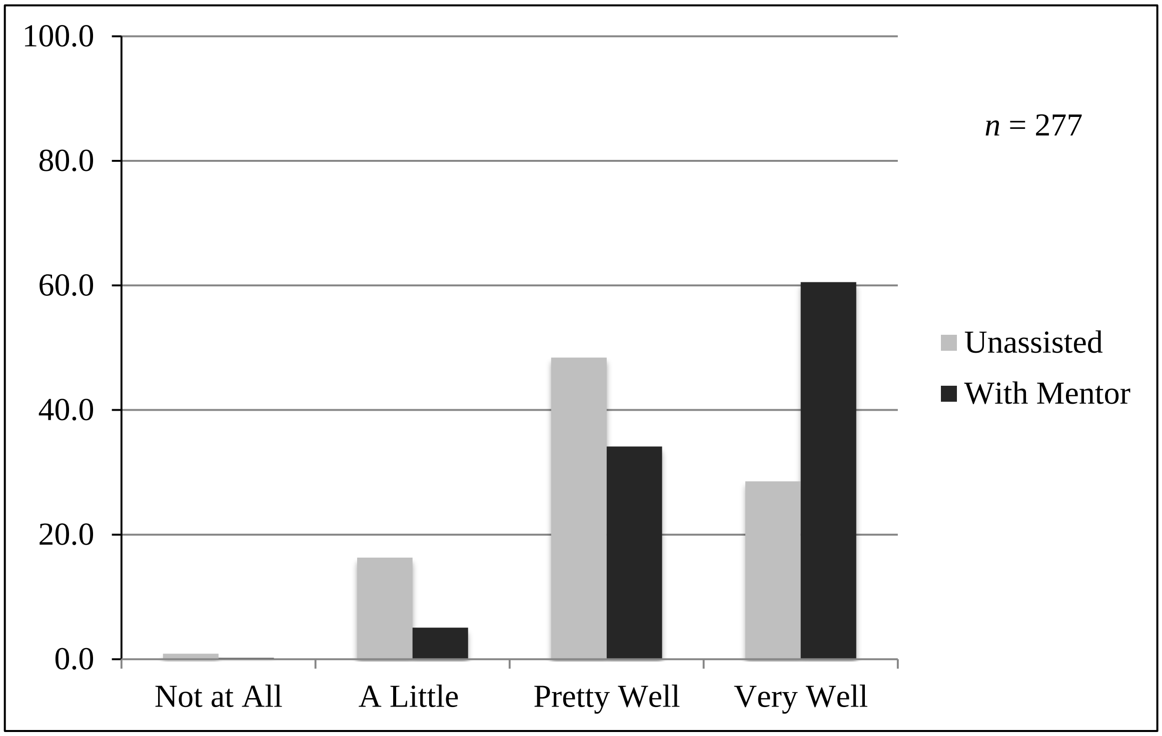

Figure 3. A comparison of student perceptions of problem solving skill unassisted and with the help of a mentor. Student rated perceptions on a 4-point Likert scale of "Not at All," "A Little," "Pretty Well," or "Very Well." For the population of 277, light gray represents student perceptions of problem solving skill unassisted, or without a mentor. Black represents student perception of problem solving skill with a mentor.

Similar results were noted for critical thinking. When working unassisted, students rated themselves as applying the skill "a little" (17.7%, *M* =49.0), "pretty well" (46.3%, *M* = 128.3), and "very well" (34.6%, *M* = 95.8). With the help of a mentor, the students' perceptions of application of their skills changed to "pretty well" (37.2%, *M* = 103.0) and "very well" (52.7%, *M* =146.0). The change in response of student perception from unassisted to mentor assistance for critical thinking is illustrated in Figure 4.

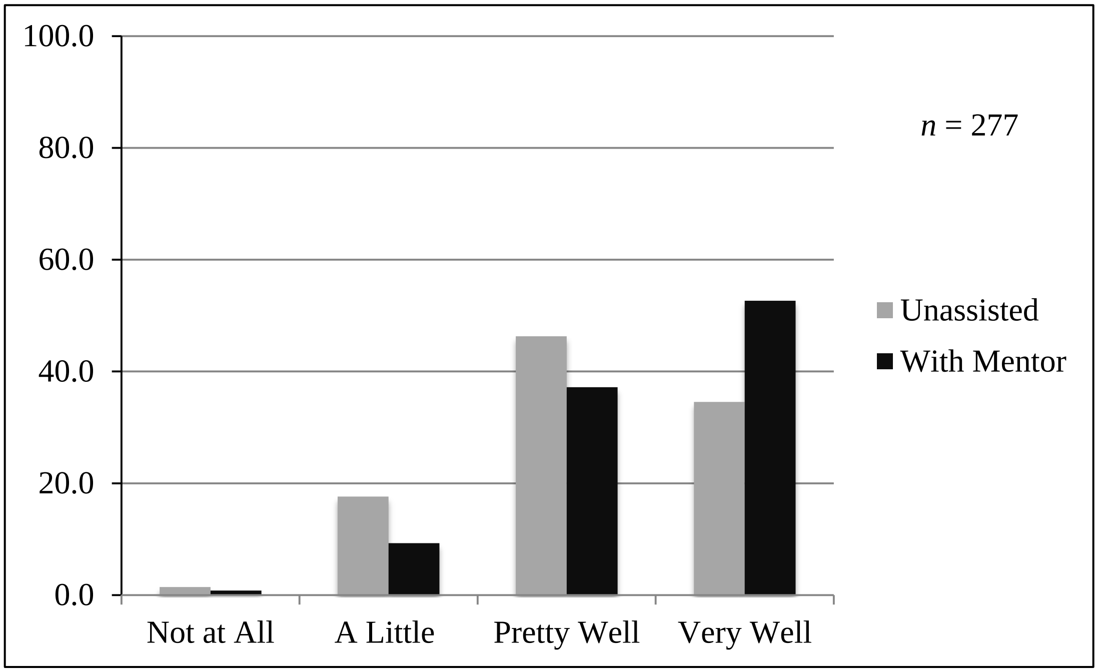

Figure 4. A comparison of student perceptions of critical thinking skill unassisted and with the help of a mentor. Student rated perceptions on a 4-point Likert scale of "Not at All," "A Little," "Pretty Well," or "Very Well." For the population of 277, light gray represents student perceptions of problem solving skill unassisted, or without a mentor. Black represents student perception of problem solving skill with a mentor.

For the teamwork skill, students rated themselves as applying the skill "a little" (8.9%, *M* =24.7), "pretty well" (47.9%, *M* = 132.7), and "very well" (42.8%, *M* =118.6) when working unassisted. With the help of a mentor, the students' perceptions of application of their skills changed to "pretty well" (35.6%, *M* = 98.6) and "very well" (57.2%, *M* = 158.4). Figure 5 shows the change in response of student perception from unassisted to mentor assistance for teamwork.

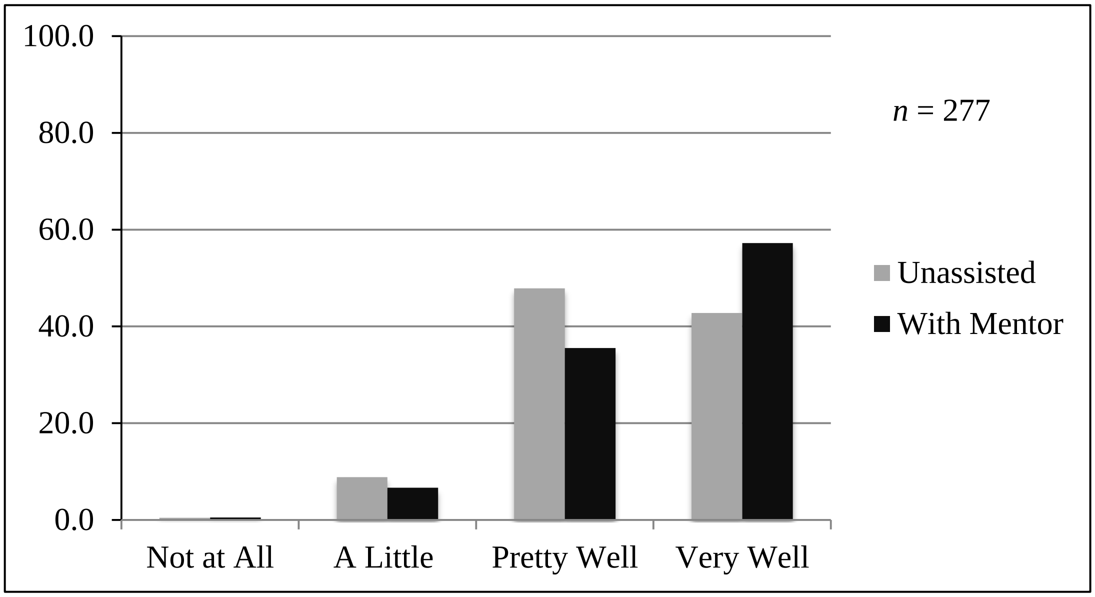

Figure 5. A comparison of student perceptions of teamwork skill unassisted and with the help of a mentor. Student rated perceptions on a 4-point Likert scale of “Not at All,” “A Little,” “Pretty Well,” or “Very Well.” For the population of 277, light gray represents student perceptions of problem solving skill unassisted, or without a mentor. Black represents student perception of problem solving skill with a mentor.

When asked about applying the communication skill, students rated themselves as applying the skill “a little” (26.5%, *M* = 73.4), “pretty well” (39.2%, *M* =108.6), and “very well” (28.7%, *M* = 79.5) when working unassisted. With the help of a mentor, the students’ perceptions of application of their skills changed to “a little” (20.1%, *M* =55.7), “pretty well” (37.4%, *M* = 103.6) and “very well” (39.1%, *M* = 108.3). Figure 6 shows the change in response of student perception from unassisted to mentor assistance for communication.

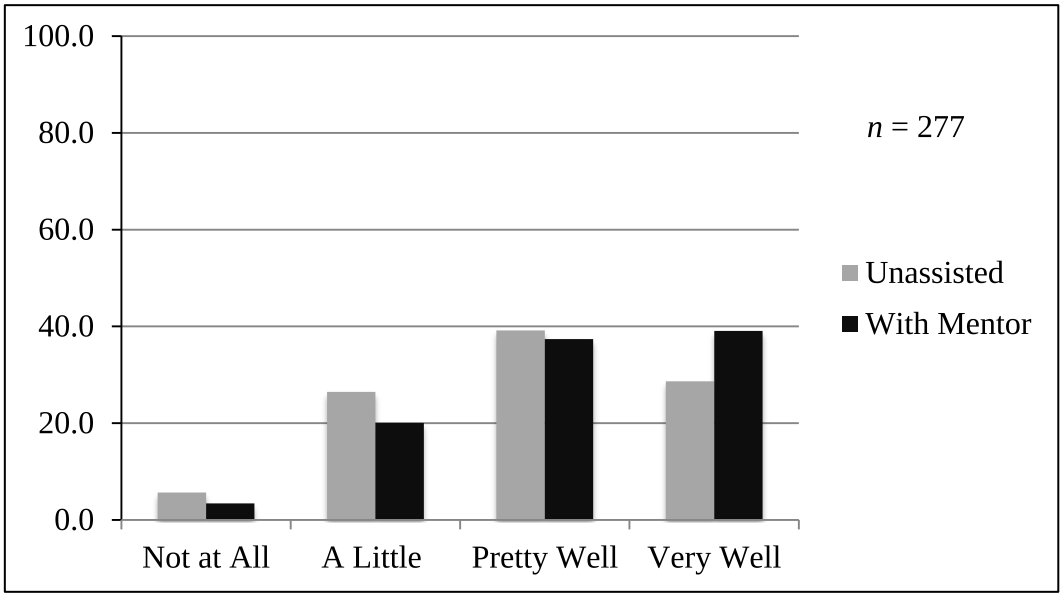

Figure 6. A comparison of student perceptions of communication skill unassisted and with the help of a mentor. Student rated perceptions on a 4-point Likert scale of "Not at All," "A Little," "Pretty Well," or "Very Well." For the population of 277, light gray represents student perceptions of problem solving skill unassisted, or without a mentor. Black represents student perception of problem solving skill with a mentor.

In addition to noting the general characteristics of student perceptions, measures of central tendency were calculated using SPSS predictive analytics software. For Research Objective 2, only the 277 surveys from students who worked with mentors were analyzed. The researcher used a *t test* to compare the means of skills with and without a mentor. The purpose of the research objective was to determine if the assistance of a mentor makes a difference in student perception of each of four workforce skills. There are several methods available for comparison of means, but a *t* test for critical value of the *t* score is appropriate when there are only two means (Huck, 2008; Walpole & Myers, 1993). The t-test parameters were alpha = .05, degrees of freedom = 276, and *t* greater than 1.984 for significance. With p = .05, the *t*-score must fall to the extreme end of the mean (2.5% on either side) to be considered significant. If the calculated *t* score is greater than 1.984, it is determined to be significant. If the *t* score is significant, mentor assistance makes a difference in student perception of workforce skills.

To determine significance, a *t* test was conducted on each of the four workforce skills. The first skill was problem solving. Five Likert items, survey questions 11, 12, 13, 17, and 25, were combined to provide interval data for analysis of student perception of problem solving skills unassisted or without the help of a mentor. These Likert items were compared to the combined value of survey questions of student perceptions of problem solving skills with mentor help (33, 34, 35, 39, and 47). Calculating student survey responses resulted in statistical significance at $t(276) = 13.44$, $p < .001$. Based on the *t*-test results, mentor assistance increases students' perception of their problem solving abilities. Table 17 describes student perceptions of problem solving skills with and without the help of a mentor.

Table 17

T-test on Student Perceptions of Problem Solving Skills With and Without Mentor Help

Workforce Skill	Unassisted		With Mentor Help			
	M	SD	M	SD	*t*(276)	*p*
Problem Solving (R1B)	10.37	2.57	12.63	2.35	-13.44	<.001

Seven survey questions (16, 19, 20, 21, 22, 24, and 26) asked student perceptions of critical thinking skills unassisted, and seven questions (38, 41, 42, 43, 44, 46, and 48) asked student perceptions of critical thinking skills with mentor help. Conducting a *t* test on the critical thinking data yielded statistical significance at $t(276) = -8.57$, $p < .001$.

The value of 8.57 is greater than 1.984, and indicates that mentor assistance affects students' perceptions of critical thinking abilities. Table 18 details *t*-test information.

Table 18

T-test on Student Perceptions of Critical Thinking Skills With and Without Mentor Help

Workforce Skill	Unassisted		With Mentor Help			
	M	SD	M	SD	$t(276)$	p
Critical Thinking (R2B)	14.81	3.41	16.87	3.44	-8.59	< .001

Similarly, for the third workforce skill of teamwork, a *t* test on the four paired survey questions (8, 9, 10, 23 and 30, 31, 32, 45) was statistically significant at the specified .05 level, $t(276) = -3.257$, $p < .001$. The value of 3.257 shows that mentor assistance is significant and positively affects student perception of collaboration skills. Details are provided in Table 19.

Table 19

T-test on Student Perceptions of Teamwork Skills With and Without Mentor Help

Workforce Skill	Unassisted		With Mentor Help			
	M	SD	M	SD	$t(276)$	p
Collaboration / Teamwork (R3B)	9.32	2.61	9.90	1.99	-3.25	< .001

Analysis of the three paired survey questions on communication (14, 15, 18 , and 36, 37, 40) also reveals mentor assistance positively affects student perception of skills.

The *t* test showed statistical significance at $t(276) = 4.410$, $p < .001$. Details are provided in Table 20.

Table 20

T-test on Student Perceptions of Communication Skills With and Without Mentor Help

Workforce Skill	Unassisted		With Mentor Help			
	M	SD	M	SD	*t*(276)	*p*
Communication (R4B)	5.62	2.13	6.27	2.11	-4.41	< .001

Analysis of Research Objective 2 shows a significant positive relationship in the role of mentors on students' perceptions in the development of four workforce skills surveyed, indicating FIRST Robotics students perceive mentors positively influence the development of problem solving, critical thinking, teamwork, and communication skills. FIRST Robotics students perceive mentors positively. T-tests support the general analysis that students perceive mentors to positively affect their skill level (as shown in Figure 3).

Research Objective 3 – Compare Differences Between Mentored and Non-mentored Students Based on Perceptions of Their Developed Skills

Statistical analysis on Research Objective 2 reveals students perceive each of the four workforce skills are increased by working with a mentor. While this determination is important, a comparison of mentored and non-mentored students can enrich the analysis and provide another level of information. Research Objective 3 compares the differences between mentored and non-mentored student perceptions of four workforce skills. Non-mentored students completed Sections 1 and 2 of the survey only, i.e., they did not complete the section asking about mentor support. For comparison of mentored to non-mentored students' perceptions of workforce skills, survey questions 8 through 26, which asked for student perception of the four workforce skills without mentor help, were used.

Of the 294 participating students, only 17 indicated they had no mentor support. A *t* test was the planned method of analysis for this objective, but the survey results were not proportional (277 mentored students versus 17 non-mentored). Because the 94.2% mentored versus 5.8% non-mentored ratio did not allow for frequency distribution analysis, a chi-square, or goodness of fit test, was used. Because there were only 17 surveys, the researcher calculated chi-square using the statistical formula. The survey used a 4-point Likert scale, so the degrees of freedom in the chi-square formula were calculated by *n*-1 or 4-1). With a confidence level of 95 and 3 degrees of freedom, the χ^2 value for significance is 7.815. Table 21 details the chi square values and significance of each of the four workforce skills analyzed in the research.

The chi square value for problem solving is 29.75 and $p < .001$ revealing significance. The significance shows there is a relationship between the assistance of a mentor and student perception of problem solving. The effectiveness of a mentor on perception of critical thinking is also significant with a chi square value of 18.86. As a proportional test, chi-square denotes significance but does not provide strength of the relationship. The effectiveness of a mentor on teamwork and communication was not significant with chi square values of 4.66 and 2.97, respectively. Because the results of teamwork and communication were not significant, a relationship between mentor help and an increase in student perception cannot be proven for those two workforce skills. Using chi-square and *t*-test inferential statistics provides quantitative information on the effectiveness of a mentor in students' perceptions of workforce skills.

Table 21

Chi-Square Test on Mentored vs. Non-Mentored Student Perceptions

Chi- Square Test on Mentored vs. Non-Mentored Students			
Workforce Skill	χ^2	p	Significance
Problem Solving	29.75	< .001	Significant
Critical Thinking	18.86	< .001	Significant
Teamwork	4.66	.198	Not Significant
Communication	2.97	.397	Not Significant

Note. Perceptions of mentored students (n = 277) are compared to perceptions of non-mentored students (n = 17) for four workforce skills.

Qualitative Data Analysis

The results of the quantitative analysis informed the qualitative phase of the research. The researcher used the quantitative findings to develop questions for a technology-enabled focus group. In addition, the researcher analyzed open-ended questions from the survey to develop the questions.

Qualitative Data Collection

Two focus group sessions were planned immediately after school to more easily fit student and coach schedules. To ensure maximum participation, students were given the option of attending on either a Tuesday or Wednesday. In the first session, four students were scheduled but only one participated. During the next session, eight students participated, and two more attempted to join but had firewall issues with the school's computer network. For the two students who had firewall issues, the researcher sent the focus group presentation to them and asked for input to the questions via email. As a result of the scheduling and firewall issues, the two planned focus groups became one interview, one focus group, and two email responses.

The researcher used Adobe® Connect web conferencing platform for the focus group presentation because it was free to the participants and did not require them to install special software. It also allowed more functionality and interactivity than a teleconference. Once an Adobe® Connect "room" is created by the researcher, participants can join "live" via an Internet link. For the research, the room was specifically designed to include photographs of the researcher and the facilitator, a slideshow presentation, and a chat box. Although Adobe® Connect has video capability, the technology was not enabled so participants could remain anonymous as promised in the school and parent permission forms. The facilitator and the participants used their computer microphones and speakers for real-time conversation, and the facilitator was able to "flip" from slide to slide in the presentation during discussion. Everyone in the room could type into the chat box at any time.

Based on literature review, the researcher chose to use a focus group to stimulate the participants' ideas and allow for thoughtful discussion (Myers, 2009). On Tuesday, the facilitator and the researcher had a detailed verbal discussion with the one participant. The participant provided rich perspective on the quantitative findings. On Wednesday, with the larger group, participants chose to use the chat box and type comments instead of talking into the computer microphones. One student did not have a microphone and had to use the chat box, but others chose to type instead of talk. The group answered all questions and responded to others' comments, but it was all accomplished via the chat box function instead of verbal conversation. The facilitator tried to provoke conversation using the flexibility within the semi-structured interview to ask the questions in different ways. However, the participants preferred to type their comments. When it became apparent that participants did not want to talk, the facilitator provided silence when necessary and read the typed comments out loud for clarity and to seek further response. Including the two participants that emailed answers to the questions, total participation was 11 students–one interviewed, eight in a focus group, and two via email.

Due to time limitations and the low number of participants who did not work with a mentor, Research Objective 3, a comparison between perceived difference in workforce skills between mentored and non-mentored students, was not included in the focus group. Of the 17 non-mentored students, six were on the team of a non-responsive coach, and others were not able to participate due to parent concerns or schedule conflict. Four of the non-mentored students were on two teams whose coaches lost the code list they were asked to keep for correlating survey numbers to student names. As noted in the methodology, the researcher only had access to survey numbers, not student names, in order to maintain anonymity. When the coaches lost the code list, the researcher was not able to correlate surveys numbers to students.

During the quantitative data analysis phase, the researcher's computer motherboard failed; the hard drive had to be physically removed and the data extracted.

The researcher was able to retrieve the survey result files but had to analyze the data through SPSS on a different computer. During the recovery and transfer to another computer, the research file with communications data was either corrupted or the wrong version was used, resulting in an erroneous *t* test. Initial *t* tests showed students perceived working with a mentor had no significance on communication skills. This incorrect finding was used when developing and conducting the focus group questions for the qualitative phase of study. Students were asked, “Why do you think a mentor’s help with communications was rated as not important?” Most were surprised and stated that they did not agree with this finding. Later review revealed the miscalculation and a new *t* test was calculated, showing significance between mentoring and communication skills. Because the question was based on erroneous data analysis and may have lead students to answer differently, the communications section of the focus group was not included in the coding process. Only open-ended questions that discussed communication were used.

Qualitative Phase of Analysis

The information provided by the quantitative data analysis informed the qualitative portion of the mixed methods research. The qualitative portion of the research was based in grounded theory as it was derived and developed from the theory that arose from the data collected (Myers, 2009).

The data resulting in the focus group questions and to the open-ended survey questions were analyzed through a three step coding process. Myers (2009) suggests emergent categories, or categories that are not predetermined but emerge from the discussion. Taylor-Powell and Renner (2003) state either preset categories or emergent categories can be used during coding. Because the focus group questions were arranged into the four categories of workforce skills, the researcher attempted to code by preset categories first. Although the focus group questions and some of the responses fit into the preset categories, some responses and many of the open-ended questions did not. To avoid misidentifying important information, the researcher started the coding process over using the emergent technique.

First Phase of Coding

During the first phase of coding with the emergent technique, all responses were grouped into categories or nodes based on the wording of the response. Categories were added to reflect the nuances in the data and until no new themes could be identified (Taylor-Powell & Renner, 2003). The coding was a combination of exact wording and descriptive coding, or abstraction from the text. Instead of using a dictionary definition for node coding, a definition was developed based on the context of the original data source (Chenail, 2012). For example, several students stated they liked “learning new things.” This was used as a category because multiple students used the same description. Other codes, such as “I get to learn from a professional,” “I get to learn from someone with many years of experience,” and “they inform us about how it is out there” were grouped under “Mentor Experience.” Some responses were grouped under multiple categories. For example, one student commented, “Mentors and their personal experiences are invaluable to aiding the team during the problem solving process, whether it be keeping us on topic or providing advice on what has worked for their own problems." This response was placed under two nodes, "Mentor Experience" and "Problem Solving."

The first phase revealed 34 nodes with 521 responses or statements that were coded. Sorting nodes showed the responses with the highest frequency. The node with the highest response rate was a positive answer to a question seeking negative aspects of working with a mentor. One of the open-ended questions was, "What do you like least about working with a mentor?" Several responses were blank and were not included in any coding; however, 72 responses (13.8%) stated, "There was nothing bad about working with a mentor" or "I liked everything about working with a mentor." Other nodes repeated with high frequency were Mentor Experience (n = 61, 11.7%), Learning New Things (n = 48, 9.2%), Helpful (n = 46, 8.8%), Can Be Controlling or Bossy (n = 37, 7.1%), Can Be Intimidating (n = 30, 5.8%), Problem Solving (n = 25, 4.8%), and Building Confidence (n = 24, 4.6%). Other nodes that expressed student thoughts and perceptions but were not as highly repeated included: Critical Thinking (n = 16, 3.0%), Guidance (n = 15, 2.8%), Fun (n = 14, 2.7%), Caring (n = 12, 2.3%), and Focus on Problem at Hand (n = 8, 1.5%). A few nodes only had one or two references, including: Boring (n = 2), Role Model (n = 1), and Steadfast (n = 1).

Second Phase of Coding

Once the raw data were coded, the researcher employed axial coding to find patterns and integrate them (Glaser & Laudel, 2013; Myers, 2009). Several of the original nodes were repetitive (i.e., Guidance and Guided Assistance) and were combined. Other nodes were combined by more closely reviewing the responses. For example, when asked about the importance of a mentor aiding with communication, nine students stated the mentors helped to teach the skill of working with others. When asked about the importance of a mentor's help in teamwork, five students said that mentors helped them learn to work with new people. The key concept of the two nodes was "working with other people," so they were combined into one node. For the purpose of this research, nodes that had only a few data points and could not be categorized more broadly were considered outliers and were not used in final analysis. For example, one student stated the mentor served as a role model. Because the researcher had no other context to determine the student's rationale, the "Role Model" node could not be sub-categorized under another node, such as "Mentor Experience," "Fun," or "Building Confidence" and was not used in final analysis.

The second phase of coding resulted in 15 categories. Of these, 417 (80.0%) responses were divided into 11 "positive" categories, 98 (18.8%) responses were grouped into three "negative" categories. Six (1.2%) responses were from students who did not work with a mentor. Because there were so few responses from non-mentored students, each comment was evaluated on its own. The 15 major categories are listed in Table 22. The four categories with the highest frequency were positive aspects of working with a mentor. The categories that ranked fifth and sixth were both negative. Of interest, the workforce skills of problem solving and critical thinking were both positive categories, but were not ranked as highly as mentor experience or learning new things. When viewed more closely, about 80% (n = 52) of the mentor experience responses included the mentor's problem solving skills or critical thinking skills.

Table 22

Major Categories Resulting from Axial Coding of Student Comments about Mentors

Coding Node	Frequency	Rank Order
No Negatives to a Mentor's Help (when asked)	72	1
Mentor Experience	65	2
Mentors are Helpful	56	3
Mentors Help Me Learn New Things	48	4
Mentors Are Controlling and Bossy	46	5
Mentors are Intimidating	42	6
Mentors Help with Critical Thinking	35	7
Mentors Help with Problem Solving	31	8
Mentors Help Build Confidence	29	9
Mentors Help with Communication and Teamwork	28	10
Mentors Provide Guidance	27	11
Mentors Are Fun	14	12
Mentors Are Caring	12	13
Student did not work with a Mentor	6	14
Mentor Cannot Always be at Practice	4	15

Students perceived the mentor’s experience as helpful in learning problem solving and critical thinking workforce skills. Examples of responses for mentor experience include:

- I think mentors build problem solving skills, because many students do not even know what problems to look for. At the beginning of the year I had no experience with robotics and I relied on my mentors and experienced students to troubleshoot and fix problems on the robot. (Categories: Mentor Experience, Problem Solving)
- Experienced mentors pay attention to details that many students overlook. Our mentors have introduced me to the proper thought processes required in the field of engineering. (Categories: Mentor Experience, Critical Thinking)

- I like the thought of an experienced person who knows a little more than I do and therefore if I have an idea they can help me fabricate or explain why or why not it is a good idea. (Category: Mentor Experience)
- Mentors provide new ways of looking at problems and can use their experience to guide students to solving them. (Categories: Mentor Experience, Problem Solving)
- You can work with people who have real working experience. (Category: Mentor Experience)
- A lot of the kids on our team look up to the mentors and see them as someone who is really experienced with the field and kind of what the real world will look like if we end up pursuing an engineering degree. (Category: Mentor Experience)

Many of the responses were similar and connected exposure to a mentor’s experience to student perception of increased problem solving or critical thinking skills.

Another theme emerged during the second coding phase. Although communication and teamwork were listed as different skills, students tended to overlap the two categories. As noted earlier, due to the researcher computer failure and a resulting data analysis mistake, the focus group question on communication was not included in the coding analysis. Only responses to open-ended questions were used. Teamwork was defined as cooperation between two or more individuals working together to solve problems, create something, or learn new content. Communication was defined as the skill of generating meaning through exchanges, either oral, written, or through body language. Still, a majority of student responses to a mentor’s help with either teamwork or communication was expressed as “working with others.” About half of the responses indicated that mentors helped students with teamwork by increasing communication among team members. Five students referred to the mentors as “referees” or “keeping everyone on the team in line.” Several students stated “without communication we couldn’t work as a team.”

While emphasis was placed on workforce skills in the focus group questions, the open-ended survey questions reveal more about mentor attributes than skills. The highest frequency positive response was to the question, “What do you like least about working with a mentor?” Seventy-two of the 277 participants (26.0%) felt so strongly about the positive aspects of a mentor that they answered the question by stating, “I like everything about working with a mentor” or “There is nothing bad about working with a mentor.” Because the students felt strongly enough about working with a mentor to include positive comments when asked for negative input, this was noted as important to the research and remained a category. Other high frequency responses grouped as categories were “Mentor Experience” (n = 65, 15.6%), “Mentors are Helpful” (n = 56, 13.4%), and “Mentors Help Me Learn New Things” (n = 48, 11.5%). A high number of responses included the words “build confidence” as 29 students (7.0%) stated they liked working with mentors because it increased confidence in their abilities. Five respondents used the term “forced outside my comfort zone” as a positive aspect of working with a mentor. The term was categorized with responses on building confidence because students expressed they had more confidence as a result of accomplishing something outside of their perceived abilities. Other responses included mentors were perceived to be fun (*n* = 14, 3.4%) and caring (*n* = 12, 2.9%).

In addition to the 417 positive responses, participants provided 98 negative responses. The negative responses were not as varied as the positive as only three categories emerged. The most common negative aspect of working with a mentor was "Mentors Are Controlling and Bossy" (*n* = 46, 47.0%). This category included comments such as:

- They sometimes take all the work
- Sometimes they take control of a certain project
- Being commanded to do things
- Sometimes take too much control
- They have the final say
- They correct your ideas before you get a chance to try them out

The second negative aspect of working with a mentor, according to student perception, was "Mentors Are Intimidating" (*n* = 42, 42.9%). About 15% (*n* = 15) of respondents noted they were nervous around adults, felt intimidated when mentors watched them work, or felt like they were not as smart as the mentors. The third negative category for mentoring was "Mentors Cannot Always Be at Practice" and was noted by only 1.5% (*n* = 2) of the students. This aspect is worth noting because the students who provided this response indicate that they depended on the mentors greatly and were disappointed when the mentors had to work and could not come to a practice or build session.

In addition to the student perceptions of mentors and their effectiveness, 17 students surveyed did not work with a mentor. As noted, none of the non-mentored students were able to participate in the focus groups, so the only input was from responses to the open-ended question, “If you do not work with an FRC mentor, how do you think your robotics experience would have been different with the help of a mentor?” Students provided six responses to the question, as follows:

- It'd be much more productive
- I wouldn't have made as many mistakes early on
- We would have a lot of help and a lot of ideas
- (Would have) helped me understand unsafe situations as they occur and new methods that could solve problems
- We probably would have gotten more work done with a mentor
- I would have learned the basics and wouldn't have made as many decisions

Although limited, the responses indicate that the non-mentored students perceived that a mentor would be helpful, especially in the areas of problem solving, learning new things, and having someone with experience.

Third Phase of Coding

Once the data were grouped and analyzed, the third and final phase of coding, theoretical coding, was used to develop themes and predictive statements to formulate a theory (Myers, 2009). During this phase, the nodes and categories were abstracted into concepts and theories (Chenail, 2012). Maintaining the general categories noted in the second phase of coding resulted in three overall descriptions of students’ perceptions of a mentor’s role: 1) Students’ Perceptions of Positive Aspects of Working with a Mentor; 2)

Students' Perceptions of Negative Aspects of Working with a Mentor; and 3) No Experience Working With a Mentor. The overall descriptions are shown in Figure 7.

With the three broad categories, the researcher noted 80% (*n* = 417) of student perceptions of working with a mentor were positive, 19% (*n* = 98) were negative, and 1% (*n* = 6) had no experience working with a mentor. Given an equal chance to answer opposing questions about working with a mentor ("what do you like most" and "what do you like least"), 4.25 times as many responses were positive as negative. This provides evidence to show students within the study population perceived mentors as an overall positive influence. Further, based on student perceptions, mentors were effective in developing the workforce skills of problem solving and critical thinking. Most important in the perception of effectiveness were mentor experience, mentor helpfulness, and the chance for students to learn new things from the mentors. Analyzing these data categories together provides a theory that can explain the reason for students' perception of mentor's role in developing workforce skills. Students perceive they learn about problem solving and critical thinking due to mentor experience in the workplace and the ability of mentors to teach new things, ideas, and concepts. With a mentor's guidance and help, students note they build confidence and discover they can work beyond their comfort zones. To a lesser degree, they learned to work with others to build teamwork through communication.

Students' Perceptions of Positive Aspects of Working with a Mentor
***n* = 417**

Negatives (when asked)
ıtor Experience
ıtors are Helpful
ıtors Help Me Learn
y Things
ıtors Help with Critical
ıking
ıtors Help with Problem
ving
ıtors Help Build
fidence
ıtors help with
ımunication and
mwork
ıtors Provide Guidance
ıtors Are Fun
ıtors are Caring

Students' Perceptions of Negative Aspects of Working with a Mentor
***n* = 98**

- Mentors Are Controlling and Bossy
- Mentors Are Intimidating
- Mentors Cannot Always be at Practice

No Experience Working with a Mentor
***n* = 6**

Figure 7. Three major categories of students' perceptions of working with a mentor.

As a negative aspect of working with a mentor, almost one-fifth of the students thought mentors were controlling and bossy or intimidating. It is noteworthy that student responses were limited almost solely to these descriptions. In fact, the descriptions of controlling and bossy or intimidating made up 90% (n = 88) of the negative responses given. This indicates a pattern and may have limited the positive responses about mentors helping students build confidence and mentors being helpful and fun.

Of the students surveyed, only 5.8% (n = 17) did not work with a mentor. Quantitative data analysis compared the differences between mentored and non-mentored students. The analysis revealed student perceptions of the differences were significant for problem solving and critical thinking. The differences between mentored and non-mentored students' perceptions of their skills in the areas of teamwork and communication were not significant. The qualitative data analysis, though limited, supports the student perception that the help of a mentor makes a difference in workforce skills as evidenced by responses about problem solving, mentor help, and more productivity. Further, students perceive they would have built a better robot and performed better with the help of a mentor.

Summary

A mixed methods sequential explanatory approach was used to determine student perceptions of the value of mentoring of FIRST Robotics teams on the development of workforce skills. Quantitative data were collected and analyzed first to inform the qualitative phase. The qualitative phase allowed for further exploration and enrichment of results of the quantitative data. Survey results and subsequent statistical analysis of the Likert items show students perceive that a mentor plays a significant and positive role in the development of the workforce skills problem solving, critical thinking, teamwork, and communication. The most significant positive differences are in problem solving and critical thinking. Based on the quantitative analysis, questions were developed for a focus group. Comments from the focus group were combined with open-ended questions from the survey for qualitative data analysis through coding. Three phases of coding reveal patterns indicating students' perceptions of mentors were largely positive. Mentor experience, helpfulness and ability to teach students new things helped students increase problem solving and critical thinking abilities and build confidence. On the other hand, mentor effectiveness can be limited by perceived negative traits such as bossiness or intimidation.

CHAPTER V

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

The national need for a technically skilled workforce has been noted in numerous studies (Jacobs, 2010; National Academy of Sciences, 2007; USDOC, 2011; Wagner, 2008). Globalization and the increased use of technology have flattened the world and require U.S. students to learn new skills (Freidman, 2005). Multiple national and international assessments such as the TIMSS and PISA demonstrate that U.S. students are not competing globally. U.S. grade school students are not learning to apply mathematics and science skills as well as other industrial countries. Within the 50 states, Mississippi and Louisiana are typically ranked in the bottom five in performance. In addition to the knowledge of classical subjects, today's students and workers need to synthesize and apply what they learn through problem solving, critical thinking, teamwork, and communication with others.

In 1991, the U.S. Department of Labor's seminal study, SCANS, listed skills necessary for success in the digital age. Almost 25 years later, the SCANS skills are still valid for today's workforce. While workforce development can occur at all stages of life, researchers advocate for workforce development training to begin in grade school as students are taught higher order thinking skills (Jacobs, 2010; Vollstedt, 2005; Wagner, 2008). As stakes in the global economy rise, schools and human resource departments seek new ways to educate the workforce (Jacobs, 2002). One popular method of workforce development is the use of mentor-based programs. Evidence shows that mentoring may promote higher order learning (Karcher, 2008; Komosa-Hawkins, 2009;

Randolph & Johnson, 2008). In the case of FIRST Robotics, mentors provide technical and applied knowledge and model workforce skills for high school students. Providing workforce development for high school robotics students enforces skills like problem solving and critical thinking.

Almost 100 years ago, Piaget's research showed interaction with the environment created learning (Mooney, 2000). Vygotsky (1978) furthers the theory of learning as a social activity and advocates the zone of proximal development, where a person can be assisted to learn with the aid of an older, more experienced person. Lave and Wenger (1991) detail the benefits of apprentice learning through the aid of a mentor. Youth mentoring is becoming increasingly popular as evidenced by over three million youth participating in formal mentoring programs (Rhodes & Dubois, 2008). There are different types of mentoring programs: some are developmental while others, such as instrumental mentoring, focus on teaching workforce skills (Karcher, 2006). The FIRST Robotics program uses an instrumental mentoring approach as it teams engineers and professionals with high school students. In fact, FIRST states that its heavy emphasis on mentors is what sets it apart as an extracurricular activity (FIRST, 2013d). This study used FIRST Robotics teams as a population to investigate student perception of the effectiveness of mentors on the development of four specific workforce skills.

Findings, Conclusions, and Recommendations

Using a sequential exploratory mixed methods approach enabled the researcher to analyze multiple forms of data. While the quantitative data provided statistical evidence of perceived mentor effectiveness, the qualitative data provided further insight into student perceptions. Five major findings were developed based on the literature review and the data analysis.

Finding 1: Students Perceive That Mentors Have a Positive Effect on the Development of Workforce Skills

The data analysis showed students perceive mentors have a positive effect on development of four specific workforce skills. In all four areas researched, problem solving, critical thinking, teamwork, and communication, students considered their performance better with the help of a mentor than without a mentor. Students rated themselves as being able to apply their skills on average about 30% better with a mentor's assistance. Inferential statistics revealed that the difference in student perceptions of their abilities with mentors was statistically and positively different than if they worked by themselves. When asked to provide comments on mentoring, student responses were overwhelmingly positive. Comparison of non-mentored to mentored students shows students perceive their workforce skills increase significantly in both problem solving and critical thinking by working with a mentor. As further evidence, non-mentored students perceive they would have better skills to build the robot if they had worked with a mentor. This evidence supports earlier research of MacDonald and Sherman (2007) and Rhodes and Dubois (2008), indicating mentoring of youth provides positive results.

Conclusion for Finding 1

The research of this study supports and adds to the body of knowledge in the field of mentoring as a means to support the development of workforce skills. For the population surveyed, the vast majority of participants perceived their skills were improved by working with a mentor.

Recommendations for Finding 1

1. Further research should be conducted to determine if the findings remain true for a larger population in FIRST Robotics.
2. The FIRST Robotics program should continue to seek and use engineering and professional mentors to provide workforce development for high school students.
3. All FIRST Robotics teams should utilize mentors to help develop workforce skills.

Finding 2: Different Types of Mentoring Can be Effective in Different Settings

Mentoring programs use various types of mentoring beyond developmental mentoring to reach youth today. Karcher et al. (2006) discuss the importance of other types of mentoring, with focus other than overall student development. For the purpose of the surveyed population, workforce mentoring was effective as demonstrated by the statistically significant data on students' perceptions of an increase in four workforce skills. The focus group elaborated on the ability of a mentor to increase problem solving and critical thinking abilities, as well as teamwork and communication. The majority of student comments on mentors included an appreciation of the mentors' expertise and technical knowledge, while there were only one or two comments on mentor traits such as steadfastness or loyalty (developmental traits). Although different types of mentoring were not part of the research objectives, one of the outcomes of the qualitative research was the benefit of mentoring focused on learning a skill rather than overall student development.

Conclusion for Finding 2

For the population surveyed in the FIRST Robotics setting, workforce mentoring rather than developmental mentoring is appropriate and effective. The goal of FIRST is to increase student interest and involvement in STEM, and working with technical mentors meets this goal. Karcher et al. (2006) refers to this type of mentoring as instrumental mentoring, where the primary goal is to learn a skill.

Recommendation for Finding 2

1. Because the research on alternative types of mentoring is relatively new (within the past 10 years), more research should be conducted on their effectiveness. In the case of FIRST, specific research on instrumental mentoring would be beneficial.

Finding 3: Student Perception of the Mentor Impacts Overall Student Experience

Several studies cite the importance of the youth's perception of the mentor as a key characteristic in the success of a mentoring program (Wheeler et al., 2010). A mentor's content knowledge and use of the knowledge is important to the students' overall experience (MacDonald & Sherman, 2007). Further, mentor enthusiasm and being able to participate in fun activities with the mentor are important to students (Rhodes, 2005). The primary purpose of this research was to determine student perception of the effectiveness of mentors in the development of four specific workforce skills. The quantitative data show that students perceived themselves to learn skills better with the help of a mentor. For all four workforce skills measured, student perception of skills increased significantly when working with a mentor. Students perceived they could apply problem-solving skills “Very Well” (60.5%, *M* = 167.6) with the help of a mentor as opposed to 28.6% (*M* = 79.2) scoring “Very Well” without the help of a mentor. This trend continued for the other skills as shown by critical thinking “Very Well” scores of 52.7% (*M* = 146.0) with a mentor and 34.6% (*M* = 95.8) without a mentor, teamwork skills of 57.2% (*M* = 158.4) with a mentor and 42.8% (*M* = 118.6) without, and communication skills of 39.1% (*M* = 108.3) with a mentor and 28.7% (*M* = 79.5) without a mentor. Applying this finding to the qualitative phase of the study reveals why the students perceived that mentors were beneficial. Student responses to the focus group questions and the open-ended survey questions were highly positive. In fact, when asked what they liked least about working with a mentor, 25% (*n* = 72) respondents enjoyed their mentor experiences enough to state there was nothing bad about working with a mentor–they liked everything. Almost 16% (*n* = 65) valued their mentors’ experience, 13% (*n* = 56) thought mentors were helpful, and over 11% (*n* = 48) appreciated mentors for helping them learn new things. Other common comments included how much the mentors helped students build confidence, how much fun they were, and how caring they were. Clearly, students valued the help of mentors.

Conclusion for Finding 3

Because mentors had experience, were fun and caring, and helped students learn new things and build confidence, students perceived their workforce skills increased in the areas of problem solving, critical thinking, teamwork, and communication. This supports evidence from earlier studies that emphasize a positive perception of a mentor by the student is key for successful mentoring.

Recommendations for Finding 3

1. The FIRST Robotics program should continue to seek and use engineering and professional mentors to provide workforce development for high school students.
2. Because the student's perception of the mentors is critical to a successful program, FIRST Robotics should ensure that training and support are provided for new and returning mentors. The FIRST Mentoring Guide, published in 2007, should be reviewed and updated.
3. Other mentoring programs should consider the importance of youth perception of mentors when implementing and conducting programs.

Finding 4: Students' Perceptions Include Common Negative Traits of Mentors

Although students' perceptions of mentors as a whole were very positive, there were two similar trends on a negative aspect of mentoring. Almost 90% of the 98 negative comments about mentors fell into one of two categories: 1) mentors can be controlling and bossy (n = 46) or 2) mentors can be intimidating (n = 42). This is the converse of Finding 3 and provides further evidence of the importance of students' perception of mentors.

Conclusion for Finding 4

As stated in Finding 3, a student's perception of a mentor is vital for success of a mentoring program. For this research, successful mentoring leads to student perception of an increase in workforce skills. The research also indicates there can be negative aspects of mentoring. More research would be needed to determine if and how the negative aspects of mentoring affect student perceptions of workforce skills development.

Recommendations for Finding 4

1. Further research should be conducted to include a larger population and to determine if the mentor characteristics of being controlling or intimidating are a common theme among students.
2. Further research should include a direct comparison to negative mentor traits and students' perceptions of workforce skills.
3. The FIRST program, as well as other mentoring programs, should provide mentor training to improve interaction with students to prevent negative traits from affecting the program.

Finding 5: Students Perception of Workforce Skills Do Not Always Match Definitions

For problem solving and critical thinking, students' perceptions of these two workforce skills rose significantly with the aid of a mentor. For students who worked with a mentor, perceptions of their teamwork and communication skills were not as significant as they were for problem solving and critical thinking. Comparison of mentored to non-mentored student perceptions did not show significance for teamwork and communication skills. When questioned, students' answers indicated they viewed teamwork and communication as the same or similar skills. Most answers for either topic included "working with others." Students felt that mentors helped with both teamwork and communication, but students did not distinguish the two as separate skills.

Conclusion for Finding 5

Student perceptions may vary from study definitions. This could be due to the age of the participant and lack of workforce experience. Or, the study may not have emphasized the differences between the two skills. The focus group data on communications was not used because the data was processed incorrectly. Further research would be needed to determine the reason for the student perceptions on teamwork and communication.

Recommendation for Finding 5

1. Conduct more research on students' perceptions of the workforce skills of teamwork and communication.

Limitations

There were a few limitations encountered during the study, and the main issues were with data collection.

Low Participation of Coaches

Coaches played a very important role in the study due to geographical dispersion and participant age. About half of the coaches were unresponsive despite repeated announcements, requests, and emails. Without the coaches' participation, the researcher had no access to the students.

Protection of Minor Participants Increased Coach Workload

Because the participants were minors, extra steps were required to ensure privacy and safety of subjects. The coaches were asked to gain school administration consent, send home and collect parent permission forms, and keep code forms with student identification for the focus groups. Several coaches noted how burdensome participation in the research was, despite the chance of winning a $150 gift certificate. A few of the coaches declined to participate after they understood the effort required for data collection.

Lack of Participation of Non-Mentored Students

The non-mentored population in this study was not large enough to compare the level of significance of students' perceptions of the effectiveness of mentors on workforce development skills. No non-mentored students participated in the focus group, so qualitative analysis was limited in this area.

Incorrect Analysis of Quantitative Data

The loss of the researcher's computer hard drive, the necessity for extraction of data files from the defunct drive, and the resulting incorrect analysis of the teamwork data limited the researcher's ability to collect data during the focus groups. The teamwork portion of the focus groups' discussion was not included in the qualitative analysis.

Recommendations for Further Study

Because this study was limited to FIRST Robotics team members in Mississippi and Louisiana, additional research is required to extend the findings to a larger population. Geographic location may play a role in student perception. It would also be important to seek a larger response from non-mentored students. In addition, as evidenced by lack of coach participation, further study is recommended to correlate the effectiveness of a coach to the success of the team and the recruitment of mentors.

Conclusion

In today's global economy, a company's workforce is its best resource for maintaining a competitive advantage (Elkeles & Phillips, 2007). Workforce development is key in maintaining this edge. However, workforce development is not limited to on-the-job training and it is not limited to working professionals. Workforce development can and should begin in elementary school and continue throughout school and into an employee's career (National Academy of Sciences, 2007, NCREL, 2003; P21, 2009: Sturtevant, 2008; USDOL, 1991; Wagner, 2008). One effective type of workforce development is mentoring (Lave & Wenger, 1991). The FIRST program states that a major difference between it and other robotics programs is the participation of mentors who serve as professional role models for the students. The guidance of mentors paired with the contextual application of robotics builds a deeper understanding of technical concepts and workforce skills.

Evidence collected during the research supports FIRST's advocacy for mentors in the learning of four specific workforce skills. Both FIRST research and the research in this study show that student's perceive working with mentors is an effective way to develop workforce skills. Students believe that they learn more about problem solving, critical thinking, teamwork, and communication due to mentors sharing their experiences. Further, students perceive mentors as fun and caring. The relationship with mentors builds student confidence and helps them learn new things. One important factor for FIRST and other mentoring programs, as evidenced by this research, is the importance of trained mentors who can provide a positive experience for the students. A mentoring program's success is based on the youth perceptions of the mentors (Wheeler et al., 2010). The input is instrumental mentoring, and the output is a perceived increase in students' workforce skills. The catalyst, however, is the student's experience with a mentor. To produce tangible workforce skills, the mentor needs to provide intangible factors–experience, fun, caring, and building of confidence. Conversely, a controlling or intimidating attitude can negatively affect student perception of workforce skills.

Because the mentoring experience can have a significant impact, either positive or negative, it is crucial for mentoring programs to incorporate current research and follow best practices for mentor training. For the FIRST program specifically, the mentoring handbook should be updated and extra training and resource materials should be considered for both experienced and new mentors.

Earlier studies by Wheeler et al. (2010) and Dubois et al. (2006) state many mentoring studies neglect participant perception–a critical component of a successful mentoring program. This research provides both quantitative and qualitative analysis from a participant viewpoint and provides the link to student perception and program success. As the United States seeks to maintain a competitive edge in today's global economy, new and innovative methods for developing workforce skills are needed. Incorporating workforce development into secondary education teaches future workers important, higher order processes such as problem solving and critical thinking. Further, mentoring can provide the real-world, experiential learning for students and teach application of skills. The findings in this research demonstrate that an experienced mentor can create a positive and impactful learning experience for students while teaching current workforce skills.

APPENDIX A

PERMISSION FROM P21

Permission to Use P21 Basic Knowledge and Applied Skills Table Email

Thank you for your inquiry,

Our materials and educator resources are free for educational purposes. We are happy to grant you permission to use P21 materials, as long as no P21 materials and references are used to imply P21 endorsement. The citation you provided looks correct. You can view full terms of use here: http://www.p21.org/our-work/use-of-p21-content

Thank you for citing P21 and the link to our website - www.P21.org.

Please let me know if you have any questions,

Administrative Coordinator
Partnership for 21st Century Skills (P21)
1 Massachusetts Avenue NW, Suite 700
Washington, DC 20001
www.P21.org

APPENDIX B

PERMISSION FROM FIRST ROBOTICS

Permission to use FIRST and Brandeis University Survey Email

Katie,

Below is the link that will take you to the study documents for the FRC teams. Please let me know if you have any questions about any of these materials. You can also reach out to Alan Melchior, the study lead from Brandeis directly at: XXXXXXX

Link to site with materials: XXXXXXX

If you use the study surveys, scales or any questions, please be sure to cite the Center For Youth and Communities at the Heller School, Brandeis University. Thanks!

And do not hesitate to contact me if you have any questions.

Warm regards,
Evaluations Manager
W www.usfirst.org

APPENDIX C

PERMISSION FROM CLAUDIA MINCEMOYER, PHD

Permission to use Critical Thinking in Everyday Life Survey Email

Hi Katie:

You have my permission to adapt questions from the Critical Thinking in Everyday Life survey for your dissertation research. Good luck with your research!

Claudia C. Mincemoyer, Ph.D.

Professor
Department of Agricultural Economics, Sociology and, Education
104 Ferguson Bldg.
University Park, PA 16802

Director, Penn State Better Kid Care Program
341 North Science Park Road
State College, PA 16803-2287

APPENDIX D

STUDENT SURVEY

Survey for FIRST Robotics Teams on the Effect of Mentors on Development of Workforce Skills

Section 1: Demographical Information

1. Team Name: ______________________________

2. Team Number: ______________________________

3. School Name: ______________________________

4. How many years have you participated in FIRST Robotics including this year? (Check one)

Number of Years

- ◯ 0 – 1 year
- ◯ 1 – 2 years
- ◯ 2 – 3 years
- ◯ More than 3 years

5. What is your primary reason for getting involved with FIRST Robotics? (Check all that apply)

Primary Reason(s)

- ◯ I was interested in science, technology and/or engineering
- ◯ It sounded cool
- ◯ I like building things
- ◯ I thought it would help me get into college
- ◯ It was part of a class at school or a home school program
- ◯ It was part of another program I was involved in (for example, an after-school club or Boys and Girls Club)
- ◯ A friend of mine was on the team
- ◯ I heard that it was fun/It looked like fun
- ◯ My parent(s)/guardian encouraged me to join
- ◯ The team leader or another adult (a teacher, team mentor, parent, etc.) asked me to join
- ◯ I had been involved in another *FIRST* program and wanted to continue my involvement
- ◯ Other (please explain) ______________________________

6. How interested are you in science, technology, engineering, and/or math (STEM)?
Please mark on a scale from 1 (not interested) to 5 (very interested).

	Not interested 1	2	3	4	Very Interested 5
Science	○	○	○	○	○
Technology	○	○	○	○	○
Engineering	○	○	○	○	○
Math	○	○	○	○	○

7. How interested are you in each of the following jobs?
Please mark on a scale from 1 (not interested) to 5 (very interested).

	Not interested 1	2	3	4	Very Interested 5
Scientist	○	○	○	○	○
Engineer	○	○	○	○	○
Mathematician	○	○	○	○	○
Computer or Technology Specialist	○	○	○	○	○
STEM Educator or Teacher	○	○	○	○	○
Inventor	○	○	○	○	○
Skilled Technician	○	○	○	○	○
Other	○	○	○	○	○

Section 2: Measure of Skills

Please mark answer on a scale from "Not at All" to "Very Well."

		Not at all	A little	Pretty well	Very well
8.	How well can you work as part of a team on a project?	○	○	○	○
9.	How well can you solve disagreements between team members?	○	○	○	○
10.	How well can you get along with other students, teachers and other adults?	○	○	○	○
11.	How well can you solve unexpected problems or find new or better ways to do things?	○	○	○	○

		Not at all	A little	Pretty well	Very well
12.	How well can you develop a plan that identifies the steps you need to follow to get something done?	○	○	○	○
13.	How well do you use trial and error to figure out if something is going to work or not?	○	○	○	○
14.	How well do you make a presentation to a group of people?	○	○	○	○
15.	How easily can you talk to adults you don't know about something you think is important?	○	○	○	○
16.	How often do you think of possible results before you take action?	○	○	○	○
17.	When facing a problem, how well do you identify options?	○	○	○	○
18.	How well can you express your thoughts on a problem?	○	○	○	○
19.	How well can you give reasons for your opinions and ideas?	○	○	○	○
20.	How important is it for you to get information to support your opinions?	○	○	○	○
21.	How well do you put your ideas in order of importance?	○	○	○	○
22.	How well do you back your decisions with information you get while researching the topic?	○	○	○	○
23.	How well do you listen to the ideas of others even if you disagree with them?	○	○	○	○
24.	How well do you keep your mind open to different ideas when planning to make a decision?	○	○	○	○
25.	How well can you determine the best way to handle a problem?	○	○	○	○
26.	How well do you make sure the information is correct?	○	○	○	○

Section 3: Mentor Effectiveness

27. How many mentors does your FRC team have?

28. Have you worked with any of your FRC team mentors?

29. If you do not work with an FRC mentor, how do you think your robotics experience would have been different with the help of a mentor?

If you answered "ZERO" to Questions 27 or 28 above, please STOP here and return your survey to the teacher.

The survey questions below are for students who have worked with or are working with a FRC team mentor.

Please mark answer on a scale from "Not at All" to "Very Well."

		Not at all	A little	Pretty well	Very well
30.	How well does your team mentor(s) help you learn work as a team on a project?	⎔	⎔	⎔	⎔
31.	How well does your team mentor(s) help you learn to solve disagreements between team members?	⎔	⎔	⎔	⎔
32.	How well does your team mentor(s) help you learn to get along with others?	⎔	⎔	⎔	⎔
33.	How well does your team mentor(s) help you learn to solve unexpected problems or find new or better ways to do things?	⎔	⎔	⎔	⎔
34.	How well does your team mentor(s) help you learn to develop a plan that identifies steps to get something done?	⎔	⎔	⎔	⎔

		Not at all	A little	Pretty well	Very well
35.	How well does your team mentor(s) help you learn to use trial and error to figure out if something is going to work or not?	⎔	⎔	⎔	⎔
36.	How well does your team mentor(s) help you learn to make presentations to a group?	⎔	⎔	⎔	⎔
37.	How well does your team mentor(s) help you learn to talk to adults you don't know about something you think is important?	⎔	⎔	⎔	⎔
38.	How well does your team mentor(s) help you learn to think of possible results before you take action?	⎔	⎔	⎔	⎔
39.	How well does your team mentor(s) help you learn to identify options when facing a problem?	⎔	⎔	⎔	⎔
40.	How well does your team mentor(s) help you learn to express your thoughts on a problem?	⎔	⎔	⎔	⎔
41.	How well does your mentor(s) help you learn to give reasons for your opinions and ideas?	⎔	⎔	⎔	⎔
42.	How well does your team mentor(s) help you learn to back your information you get while researching the topic?	⎔	⎔	⎔	⎔
43.	How well does your team mentor(s) help you learn to put your ideas in order of importance?	⎔	⎔	⎔	⎔
44.	How well does your team mentor(s) help you learn to support your decisions with researched information?	⎔	⎔	⎔	⎔
45.	How well does your team mentor(s) help you learn to listen to the ideas of others even if you disagree with them?	⎔	⎔	⎔	⎔
46.	How well does your team mentor(s) help you learn to keep your mind open to different ideas?	⎔	⎔	⎔	⎔
47.	How well does your team mentor(s) help you learn to determine the best way to handle a problem?	⎔	⎔	⎔	⎔
48.	How well does your team mentor(s) help you learn to make sure all the information is correct?	⎔	⎔	⎔	⎔

49. What do you like most about working with a mentor?

50. What do you like least about working with a mentor?

APPENDIX E

IRB APPROVAL

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5116 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional-review-board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
  Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **Katie Wallace**
PROJECT TITLE: **Student Perceptions of the Value of Mentoring of First Robotics Teams on the Development of Workforce Skills**
PROJECT TYPE: **New Project**
RESEARCHER(S): **Katie Wallace**
COLLEGE/DIVISION: **College of Science and Techonlogy**
DEPARTMENT: **Human Capital Development**
FUNDING AGENCY/SPONSOR: **N/A**
IRB COMMITTEE ACTION: **Expedited Review Approval**
PERIOD OF APPROVAL: **12/16/2013 to 12/15/2014**

Lawrence A. Hosman, Ph.D.
Institutional Review Board

APPENDIX F

LETTER TO COACHES

(Description: Email format)

From: Katie Wallace

Date: December 17, 2013

Subject: Request for Help in FRC Study and Chance to Win a $150 Home Depot Gift Card

Hello FRC Coaches!

Thank you for volunteering to be a FIRST Robotics team coach! You are making a difference in the lives of many high school students.

As part of my doctoral studies, I am researching the effect of mentors on the development of workforce skills. I am seeking the opinions of FIRST team members and need your help to obtain survey information from FRC students. I am asking each coach to administer a survey in a group setting during the build / competition season. The results will be used to help FIRST and NASA understand the effectiveness of mentors in preparing students to work in today's global economy.

For participating teams, prizes include:

- Return of signed administration and parent permission slips within two weeks of receipt = one team entry for one of two $150 Home Depot gift cards
- Over 50% participation in student survey within three weeks of receipt = second team entry for one of two $150 Home Depot gift cards
- Over 90% participation in student survey within three weeks of receipt = third team entry for one of two $150 Home Depot gift cards
- Participation in Student Focus Group (random selection) = one student entry for one of two $50 Best Buy gift cards

To participate, coaches must:

1) Distribute and collect administration and parent permission forms
2) Administer and return the student survey (paper copies returned by mail - postage paid envelope included)
3) Keep a list that correlates unique survey code to student name. This list is not to be shared with anyone, including the researcher. The code will be used to randomly select students for the technology-enabled focus group.

4) If one of your students is asked to participate in the focus group, please facilitate his participation via videoconference and attend as an observer.

Participation in the study is completely voluntary and will include completion of one student survey by team members (20 minutes) and potentially focus group participation by one student (conducted by videoconference for up to 1 hour). Surveys are anonymous and students are not tracked by demographics other than school name and FRC team number. The focus group will be audio recorded to ensure that all participant comments are heard correctly and can be grouped into research categories. The researcher will be the only person with access to the audio recording and it will be destroyed when the research is completed. There are no known risks for participation in the study.

This project has been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations.

Please email me if you are interested in participating. If you have any questions or concerns at any time, please call or email me. Thank you very much for your time, help, and expertise!

Sincerely,
Katie Wallace

APPENDIX G

LETTER TO SCHOOL ADMINISTRATION

Katie Veal Wallace
Researcher Address
Researcher Address
Date

School Administrator
School Name
School Address
City, State ZIP

Subject: Request for FIRST Robotics Team Participation in Dissertation Research

Dear (Administrator Name):

Thank you very much for supporting the FIRST Robotics team at your school. The FRC program is a real-world challenge that allows students to learn hands-on skills and test their capabilities.

I work for the National Aeronautics and Space Administration (NASA) on robotics education, a $4.2 million per year program. Many NASA employees serve as mentors to local teams. As part of my doctoral studies, I am researching the effect of mentors on the development of workforce skills. These skills include problem solving, critical thinking, communication, and collaboration. The results of this study will be used to inform both FIRST and NASA on student perception of the effectiveness of mentors in preparing students to work in today's global economy.

The research seeks the opinion of FRC students from every FRC team in Mississippi and Louisiana. I would like to ask your permission for school participation in the research.

Participation in the study is completely voluntary, and participants can withdraw at any time without penalty, prejudice, or loss of benefits. It will include completion of one student survey (about 20 minutes) and potentially a focus group (conducted by videoconference for up to one hour). All surveys will be anonymous, and students will not be tracked by demographics other than school name and FRC team number. There are no known risks associated with participation in the study.

In addition, all aspects of the research have been approved by the University of Southern Mississippi Institutional Review Board to ensure that students are treated ethically and that their rights and welfare are adequately protected.

The participation for each team, to be administered by the team coach, will be:

1. Completion of the parent/student permission forms.
2. Completion of the survey, with hard copy submitted via mail (postage paid envelope included).
3. Help with random selection of focus group participants.
4. Support of video participation in a focus group by one student if school is selected.

For participating teams, prizes include:

- Return of signed student and parent permission slips within two weeks of receipt = one team entry for one of two $150 Home Depot gift cards
- Over 50% participation in student survey by January 15, 2014 = second team entry for one of two $150 Home Depot gift cards
- Over 90% participation in student survey by January 15, 2014 = third team entry for one of two $150 Home Depot gift cards
- Participation in Student Focus Group (as selected by your coach) = one student entry for one of two $50 Best Buy gift cards

If you have any questions or concerns at any time, please call or email me. Thank you very much for allowing your school's FRC team to participate in this research.

Sincerely,
Katie Wallace

Dissertation Study on the Topic of
The Effect of Mentors on Development of Workforce Skills

SCHOOL ADMINISTRATION PERMISSION FORM

I give permission for my school, ___________________________________, to participate in a doctoral study on the effectiveness of FIRST Robotics mentors on the development of workforce skills.

Specifically, I understand that students from my school will be completing a survey about robotics, mentorship, and skills from mentors. The survey will be anonymous and will only ask for student's school, robotics team number, and high school grade level. I understand that all responses to the survey will be kept strictly confidential and will only be used for the purposes of this study. As part of the study I also understand that my school's students may be asked to be part of a focus group. This may include being audiotaped. Again, I understand that any information collected will be used only for the purposes of the study. The researcher will work through the team coach for data collection, and any contact for the purposes of this study will be done through the coach.

Please Check:

_____ **YES,** I give permission for my school's robotics team to participate in a survey on the effectiveness of FRC mentors on the development of workforce skills.
_____ **YES**, I give permission for my school's robotics team to participate a focus group on the effectiveness of FRC mentors on the development of workforce skills (only 5-10% of participating students will be chosen).
_____ **NO,** I do not give permission for my school's robotics team to participate in a survey on the effectiveness of FRC mentors on the development of workforce skills.

____
School Name (printed)

____
Administrator's Name/ Title (printed) Administrator's Signature Date

Please return this permission slip in the self-addressed, stamped envelope.

APPENDIX H

LETTER/PERMISSION FORM TO PARENTS

Dissertation Study on the Topic of

The Effect of Mentors on Development of Workforce Skills

For: FIRST Robotics Team Parents in Mississippi and Louisiana
Date: January 5, 2014

Hello FRC Parents!

Congratulations on your child's participation in FIRST Robotics! A large part of the FIRST Robotics Competition is the help of professional and engineering mentors. As part of my doctoral studies, I am researching the effect of mentors on the development of workforce skills, or skills that your child can use in a job.

I am seeking the opinion of FIRST team members and need your help to get survey information from your child. Participation in the study will include completion of one student survey (about 20 minutes). Additionally, 7-12 students from the Mississippi and Louisiana area will be asked to participate in a focus group that will be conducted by videoconference for up to 1 hour. Participation in the study is completely voluntary and students may withdraw at any time without penalty, prejudice, or loss of benefits. All surveys and focus group will be anonymous and students will not be tracked by name or demographics other than school name and FRC team number. There are no known risks for participation in the study. There is a unique code on each survey that will be used to ensure random selection of focus group members. The teacher will keep a list that correlates the code to student name. The researcher will not have access to the list. Once the focus group is selected, the teacher will shred the code list. If a student is selected, has parent approval, and chooses to participate in the focus group, Mr. Chris Copelan, local FIRST emcee and mentor, and I will serve as moderators. Your child's coach will be present at all times. The focus group will be audio recorded to ensure that all participant comments are heard correctly and can be grouped into research categories. The researcher will be the only person with access to the audio recording and it will be destroyed when the research is completed.

For participating teams, benefits include:

- Return of signed student and parent permission slips within two weeks of receipt = one team entry for one of two $150 Home Depot gift cards
- Over 50% participation in student survey within three weeks of receipt = second team entry for one of two $150 Home Depot gift cards

- Over 90% participation in student survey within three weeks of receipt = third team entry for one of two $150 Home Depot gift cards
- Participation in Student Focus Group = one student entry for one of two $50 Best Buy gift cards

The results of this study will be used to inform both FIRST and NASA of the student perception of the effectiveness of mentors in preparing students to work in today's global economy. If you allow your child to participate, both you and your child must sign the permission form attached.

This project and its consent form have been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Manager of the IRB at (601) 266-5997. Questions concerning the research, at any time during or after the project, should be directed to Katie Veal Wallace at (phone) or (email).

Sincerely,
Katie Veal Wallace

Dissertation Study on the Topic of
The Effect of Mentors on Development of Workforce Skills

STUDENT / PARENT PERMISSION FORM

I give permission for my child, ___________________________________, to participate in a doctoral study on the effectiveness of FIRST Robotics mentors on the development of workforce skills.

Specifically, I understand that my child will be completing a survey about robotics, mentorship, and workforce skills. The survey will be anonymous and will only ask for school name and robotics team number. I understand that all responses to the survey will be kept strictly confidential and will only be used for the purposes of this study. As part of the study I also understand that my child may be asked to be part of a focus group. This may include being audiotaped. Again, I understand that any information collected will be used only for the purposes of the study. The researcher will work through the team coach for data collection, and any contact for the purposes of this study will be done through the coach. There are no known risks for participating in the study.

If I would like more information about the study or to hear an oral presentation of the purpose, risks, and benefits, I can call or email the researcher, Katie Veal Wallace at (phone) or (email).

Please Check:

_____ **YES**, I give permission for my child to participate in a survey on the effectiveness of FRC mentors on the development of workforce skills.
_____ **NO**, I do not give permission for my child to participate in a survey on the effectiveness of FRC mentors on the development of workforce skills.

_____ **YES**, I give permission for my child to participate a focus group on the effectiveness of FRC mentors on the development of workforce skills (only 7-12 of participating students will be chosen).
_____ **NO**, I do not give permission for my child to participate a focus group on the effectiveness of FRC mentors on the development of workforce skills (only 7-12 of participating students will be chosen).

____

Parent's Name (printed)   Parent's Signature   Date

Please return this form to your child's robotics coach.

APPENDIX I

SHORT PERMISSION FORM FOR STUDENTS

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

AUTHORIZATION TO PARTICIPATE IN RESEARCH PROJECT

Participant's Name ___________________________

I understand that by signing this form, I am agreeing to participate in the research project titled "Student Perceptions of the Value of Mentoring of FIRST Robotics Team on the Development of Workforce Skills." All procedures for the study and purpose for the procedures were explained by _________________. I was given information about all benefits, risks, inconveniences, or discomforts that I may feel while participating.

I had the opportunity to ask questions about the research and procedures. I understand that participation is completely voluntary, and I can withdraw at any time without penalty, discrimination, or loss of benefits. All personal information is strictly confidential, and my name will not be disclosed. I also understand that the researcher will let me know if any new information develops during the project that might change my willingness to continue participation.

Questions concerning the research, at any time during or after the project, can be sent to Katie Wallace at (phone) or (email). This project and this consent form have been reviewed by the Institutional Review Board to make sure research projects involving human participants follow federal regulations. Any questions or concerns about my rights as a research participant should be sent to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-0001, (601) 266-5997.

A copy of this form will be given to the participant.

____ ____________________

Signature of participant Date

____ ____________________

Signature of person explaining the study Date

APPENDIX J

ORAL PRESENTATION FOR SURVEY ADMINISTRATION

Oral Presentation for

Survey for FIRST Robotics Teams on the Effect of Mentors on Development of Workforce Skills

The purpose of this survey is to measure the effectiveness of FIRST Robotics on the development of workforce skills, or skills that you can use in a job. The researcher, Katie Wallace, needs the opinions of FIRST team members and wants your help. The results will help FIRST and NASA understand the how mentors help prepare students to work in today's global economy.

You can help by completing a 50-question survey that takes about 20 minutes. There are a few essay questions, but most consist of answering on a scale of "Not at All" to "Very Well." You may skip any questions that you do not feel comfortable answering. After the survey results are recorded, 7-12 students from across Mississippi and Louisiana will be selected to be part of a videoconference focus group that will last for up to one hour. This focus group will be audio recorded and I (your teacher) will be present at all times.

This is how the team can get prizes:

- Returning signed permission slips = one team entry for one of two $150 Home Depot gift cards
- 50% of your team completes the survey = second team entry for one of the two Home Depot cards
- 90% of your team completes the survey = third team entry for one of the two Home Depot cards
- Participation in Student Focus Group = one student entry for one of two $50 Best Buy gift cards

There are no known risks from participating in this activity. Participation is completely voluntary and you may withdraw at any time without penalty, prejudice, or loss of benefits.

Any information you provide will remain confidential. All surveys and the focus group will be anonymous, and you will only be tracked by school name and FRC team number. You will see a code on your survey. This code is unique to your survey. I (your teacher) will keep a list that correlates the code to your name. The researcher will not have access to the list of names. The code will be used to make sure focus group participants are randomly selected. Once the focus group is selected, I will shred the code list. If you are selected and choose to participate in the focus group, it will be moderated by Mr. Chris

Copelan, local FIRST emcee and mentor, and Ms. Katie Wallace, researcher and FIRST volunteer.

This project and its consent form have been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about your rights as a participant should be directed to the Manager of the IRB at (601) 266-5997. Any questions about the research should be directed to Katie Wallace.

APPENDIX K

FOCUS GROUP SCRIPT

GUIDELINES:

•**Thank you very much for your participation!!**

•You should see a presentation on the computer screen
•There is a chat box if you would like to type in comments
•Please mute your microphone unless speaking
•This is voluntary
•This will be recorded
•This will take one hour
•There are no wrong answers
•Participants will be entered into a drawing for one of two $50 gift cards (of your choice)

PURPOSE:

•This focus group is based on the surveys that you took during build season

•Research: Student perception of the effectiveness of a mentor

•All participants are on FIRST Robotics teams

•Four workforce skills researched:
- •Problem Solving
- •Critical Thinking
- •Teamwork
- •Communication

TOPIC 1: PROBLEM SOLVING

Problem Solving: the ability to solve different kinds of non-familiar problems in different ways.

Example: How well can you solve unexpected problems for find new or better ways to do things?

Question: The surveys showed that mentors are very important in helping students develop problem-solving skills. Why do you think a mentor's help on problem solving was rated as important?

TOPIC 2: CRITICAL THINKING

Critical Thinking: Skill that uses rationalization and evaluation to align thoughts and actions.

Example: How well can you give reasons for your opinions and ideas? How well do you put your ideas in order of importance?

Question: The surveys showed that mentors are very important in helping students develop critical thinking skills. Why do you think a mentor's help on critical thinking was rated as important?

TOPIC 3: TEAMWORK

Teamwork: Cooperation between two or more individuals working together to solve problems, create something new or learn content.

Example: How well can you work as part of a team on a project?

Question: The surveys showed that mentors are important in helping students develop teamwork skills. Why do you think a mentor's help on teamwork was rated as important?

TOPIC 4: COMMUNICATION

Communication: the skill of generating meaning through exchanges, either oral, written, or through body language.

Example: How well can you express your thought on a problem?

Question: The surveys showed that mentors are not important in helping students develop communication skills. Why do you think a mentor's help with communications was rated as **not** important?

CONCLUSION

•Thank you again for your time and input!

•We hope you have a wonderful summer

•Teachers will be notified of the winners

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