# THE EFFECTS OF THE NXT ROBOTICS CURRICULUM ON HIGH SCHOOL STUDENTS' ATTITUDES IN SCIENCE BASED ON GRADE, GENDER, AND ETHNICITY

A Dissertation

Presented to

The Faculty of the School of Education

Liberty University

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Education

By

Sandra Lyn Jewell

The Effects of the NXT Robotics Curriculum on High School

Students' Attitudes in Science Based on Grade, Gender, and Ethnicity

By Sandra Lyn Jewell

APPROVED:

| | |
|---|---|
| COMMITTEE CHAIR | Tracey B. Pritchard, Ed.D |
| COMMITTEE MEMBERS | Jeffrey Savage, Ed.D |
| | Jerry V. Congleton, Ed.D |
| CHAIR, GRADUATE STUDIES | Scott B. Watson, Ph.D |

ABSTRACT

Sandra Lyn Jewell. THE EFFECTS OF THE NXT ROBOTICS CURRICULUM ON HIGH SCHOOL STUDENTS' ATTITUDES IN SCIENCE BASED ON GRADE, GENDER, AND ETHNICITY (Under the Direction of Dr. Tracey Pritchard) School of Education.

This study examined the effects of the NXT Robotics curriculum on high school students' attitudes about science. A quasi-experimental research design was employed in the evaluation of the NXT Robotics class. The program was evaluated by comparing the attitudes and interests of 57 students who participated in the elective NXT Robotics class and not a science class, and 57 students who participated in a science class and not the elective NXT Robotics class. While a treatment group and a control group were compared, the groups were intact groups chosen out of convenience rather than through random assignment into the treatment and control groups.

The Test of Science-Related Attitude (TOSRA) was given to students through a pretest and posttest spaced 8 weeks apart. The students were surveyed to determine their attitudes concerning, science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science, based on grade level, gender, and ethnicity. Analysis of covariance (ANCOVA) served as the method of data analysis for the study.

The data used in this research study determined that for attitude of science inquiry there was little difference by grade level, gender, and ethnicity. The analysis of the data for enjoyment of science lessons showed a significant difference between 12$^{th}$ and 9$^{th}$ grade students and 12$^{th}$

and 10th grade students by grade level. There was very little difference between the males and females. By ethnicity there was a significant difference between the White, non-Hispanic and Black, non-Hispanic students. The data for leisure interest in science showed very little difference by grade level and gender, but a significant difference by ethnicity between the White, non-Hispanic and Black, non-Hispanic students. The data analyzed for career interest in science showed a significant difference by grade level between 9th and 11th graders and between 9th and 12th graders. There was very little difference between the genders, but for ethnicity there was a significant difference between the Black, non-Hispanic and the White, non-Hispanic students. There was also a significant difference between the Black, non-Hispanic and Hispanic students for career interest in science.

Acknowledgements

I would like to thank Dr. Tracey Beno Pritchard, my committee chair, for all her support and words of encouragement throughout this endeavor. I would also like to extend my thanks to Dr. Susan Twaddle, who helped me finally understand the power of statistics when determining if an educational program is vital to a school division. I would like to extend my thank you to Dr. Savage, for his expertise on how to improve the final version of my dissertation. Dr. Congleton, I want to thank you for your support and encouraging words during and after the final defense presentation.

Dedications

I would like to dedicate this body of work to two people in my life who have been there for me, encouraging me and refusing to let me quit even when I wanted to: Bill, my soul mate, has endured my frustrations and deserves credit for being my everyday support through this paper, and Kristin, my daughter, who was with me when I started my educational career and has seen me through more bumps in the road than anyone should ever have to. Kristin, you were there for me in the beginning and now at the end. Thank you. I hope to one day repay the support. I love you both and could never have gotten this far without the two of you behind me.

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

# CHAPTER ONE: INTRODUCTION

"I am not sure you can teach innovation, but you can unteach it.

I think every kid starts out as a scientist."

Dean Kamen - Founder of FIRST

August 27, 2009 Forbes.com

In the United States, schools are largely viewed as settings where students progressively learn the skills needed to be successful in adulthood. Success, defined broadly from an educational standpoint, means anything from attaining postsecondary education to learning the skills necessary to be a productive member of the workforce (Daniel, 2006). "Elementary and secondary schools were given a challenge for the 21st Century, for students to study the sciences, technology, engineering and mathematics (STEM) beyond the confines of federally mandated tests" (North Central Regional Education Laboratory, 2003). The Department of Education in Virginia requires high schools to offer core science and mathematics classes but not technology or engineering classes. The elective NXT Robotics class curriculum encompasses all aspects of science, technology, engineering, and mathematics (STEM) education. This researcher conducted a quantitative study of the NXT Robotics curriculum to analyze how it affects high school students' attitudes and interests towards science.

Forty years ago, President John F. Kennedy challenged the nation to greatness in the sciences. In a speech given before Congress on May 25, 1961, he said, "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth." Americans rose to the challenge and accomplished that lofty goal (National Science Foundation, 2009). On July 20, 1969, Neil Armstrong and Edwin Eugene "Buzz" Aldrin became the first humans to land on the moon (Blake, 2010). The challenge for educating students for the 21st century is no less lofty than the one put before Americans more than 40 years ago.

Today's students have made great strides in learning how to take tests but are graduating without understanding how the sciences apply to their everyday lives; in response to this, there has been a renewed interest in STEM education for the K-12 school systems (North Central Regional Educational Laboratory, 2003). Students who complete their K-12 education in the United States lag behind students in other countries in science, mathematics, reading, and problem-solving skills (Berube, 2004; Genalo, 2004; National Academy of Science, 2009). STEM education in the K-12 school system is offered in some school divisions and not in others; it depends on the mission and goals of each individual school division. STEM education in K-12 schools is sometimes limited because of financial resources.

The rural school division in this study has provided the mission, goals, and funds to implement an elective NXT Robotics class on the secondary level. The National Academy of Science, the National Academy of Engineering, and the Institute of Medicine issued a joint report calling for the reinventing of STEM education primarily though postsecondary education (National Academy of Science, 2005). The recommendations in this report were to increase funding for STEM programs, to increase the STEM teaching pool, and to increase the number of students pursuing degrees and careers in STEM fields.

> The National Academy of Science reported having reviewed trends in the United States and abroad, the committee stated that the scientific and technological building blocks critical to our economic leadership are eroding at a time when many other nations are

gathering strength. We fear the abruptness with which a lead in science and technology can be lost–and the difficulty of recovering a lead once lost, if indeed it can be regained at all. (National Academy of Science, 2005 p.5)

A 2006 National Academies committee report calling for improvement in K-12 science and mathematics education listed the falling rate of innovation in the United States and the increase in outsourcing of information technology jobs to other countries as being among the reasons for concern about the inadequate size of the nation's locally developed talent pool in math, science, and engineering.

This was not the first time a STEM initiative was brought before the public. Other agencies have made similar statements (National Science Board 2007; U.S. Department of Education 2006). On April 27, 2009, President Barack Obama stated that he would make it a national imperative to dramatically improve student achievement in math and science. His goal was to move students in the United States from the middle of the pack to the top on international benchmarks over the next decade and to challenge all Americans to dramatically increase support for math and science education (Obama, 2009; Office of Science and Technology Policy, 2009). This challenge inspired numerous school divisions to implement new inventive programs in their schools to address the lack of STEM education.

The United States Department of Education (2008) released a report containing information regarding the number of students completing degrees in the STEM fields. The report determined that it is essential that primary and secondary students are prepared to go into the fields of STEM education. The problem becomes disconcerting when looking specifically at the demographics of students entering STEM disciplines. On the postsecondary level the percentage of males entering STEM fields was higher than that of females, 33% vs. 14%, and nearly half of the students were Asian/Pacific Islander (47%) compared to 19-23% of students in other racial/ethnic groups (National Center for Education Statistics 2009, p. 161; United States Department of Education, 2008).

A higher percentage of international students (34%) entered STEM fields than students from the U.S. (22%). This was especially conspicuous when comparing international students and students from the United States in the computer/information sciences, where the percentages were 16% vs. 6% (National Center for Education Statistics, 2009, p.161; United States Department of Education, 2008). The article "Tapping American's Potential" (2006) said that China graduates four times as many engineers as the United States. The percentage of students entering STEM fields was highest among students who took trigonometry, precalculus, or calculus in high school and had college entrance exam scores in the highest quarter (National Center for Education Statistics, 2009, p.162; United States Department of Education, 2008).

Dean Kamen (1989), an inventor and entrepreneur, founded FIRST (For Inspiration and Recognition of Science and Technology), a robotics competition for high school students. FIRST is an international non-profit organization that has developed into a program that offers different grade levels of competition for students: JFLL (Junior First Lego League), grades K-3; FLL (First Lego League), grades 4-8; FTC (First Tech Challenge) and FRC (First Robotics Challenge), grades 9-12 (FIRST Robotics Team Information, 2006). Kamen (1989) has enabled students across the world to participate in STEM competitions that rival a sporting competition. His goal for FIRST was to "create a world where science and technology are celebrated …where young people dream of becoming science and technology heroes" (U.S. FIRST, 2006, p. 1). In 2009, all the programs combined had a total of 213,000 student participants; there were 19,200 teams, 17,700 robots, 57,200 mentors, and 32,000 event volunteers (FIRST Robotics Team

Information, 2009). The FIRST organization has guided students in the exploration of the sciences for 20 years. The cost of the program for each team is absorbed through volunteers, donations, school divisions, and fund raisers. Each of the FIRST programs is approximately six to ten weeks long. Besides building the robot, students in the FIRST programs also participate in a number of other activities geared towards getting them excited about STEM disciplines.

Research on the FIRST program has concluded that FLL, FTC, and FRC are successful in involving students in STEM programs, but no empirical evidence exists that indicates an increase or change in students' attitudes toward or interest in science (Goodman Research Group, 2000). The FLL, FTC, and FRC programs have a six-to-ten week building window in which the students have a set goal for completion of their robot. The curriculum used for the elective NXT Robotics class is a semester-long program with the students having the option to change the design of their robot to complete a task put before them. Robotics is a multidisciplinary field that combines mechanical, electrical, electronic engineering, and computer science. Even though robots are very complex machines and building robots requires a range of skills, current technology and related, age-appropriate pedagogies make it possible for everyone to build, program, and control their own robots (Jawaharial, Larriva, & Nemiro, 2007).

The success of the FIRST program has given rise to for-profit companies developing their own robotics curriculum. One company, LEGO Education, has teamed with FIRST to develop the robot that is used for the FTC and FLL competition, the NXT Lego Mindstorm. The robots are available for sale to the general public, a situation which has spurred the company in conjunction with Carnegie Mellon University to develop a robotics academy for K-12 students. The Robotics Academy's mission is to use the motivational effects of robotics to excite generations of students to pursue math and science-related careers. Robotics Academy curriculum can be found in over 8,000 schools internationally (Robotics Academy, 2008). The curriculum used by the elective NXT Robotics classes in this study was developed at the Robotics Academy Robotics Engineering volumes I/II and the Science and Data Logging programs. This robotics curriculum was implemented for the rigorous lessons that provide differentiation of instruction and problem-solving activities for the novice through experienced students.

The curriculum resources are available for K-12 schools to implement Robotic STEM educational programs into their school divisions. This study is designed to determine if the NXT Robotic curriculum being taught in a rural school division high school has a positive effective on student attitudes about interests in science. The National Science Foundation (NSF) definitions of STEM fields include not only mathematics, natural sciences, engineering, and technology, but also psychology, economics, sociology, and political science. In this study, the STEM field of engineering will be discussed. The NXT Robotics elective will be an individual and group project-based class that does not use summative assessments such as required state-mandated tests. Teachers will observe students individually in day-to-day activities through formative assessments and classroom discussions.

Nearly all aspects of everyday life require an understanding of science and technology concepts and skills. The North Central Regional Educational Laboratory (NCREL) (2003) posits that as society changes, the skills needed to negotiate the complexities of life also change. In the early 1900s, a person who had acquired simple reading, writing, and calculating skills was considered literate (Berube, 2004). According to the International Reading Association "that only in recent years has the public education system expected all students to build on those basics, developing a broader range of literacies" (ICT, 2002, p.12). To achieve success in the

21st century, students also need to attain proficiency in science, technology, and culture, as well as gaining a thorough understanding of information in all its forms (NCREL, 2003).

The elective NXT Robotics classes were developed to expose secondary students to the sciences; the students apply what they have learned in their math, science, and reading classes into lessons on building and programming robots. Through this exposure, students' attitudes and interest in the sciences are likely to shift more towards future educational endeavors (Center for Engineering Education Outreach, 2009).

**Statement of Problem**

With the passing of NCLB requirements, school divisions are focused on high-stakes testing in the core subjects. Science has changed; teachers are teaching the students to pass a test in order for the schools to make Adequate Yearly Progress (AYP). Students are learning science so that they can receive a passing score on required standardized tests, and they are receiving test preparation lessons; this has led to a lack of innovative teaching (Rogers, 2006). Losen and Wald (2005) said that many students are graduating from high school without the knowledge necessary to make an informed decision on postsecondary educational interests and careers in the sciences. The Education Commission of the States (2004; as cited in Cooper, 2006) said that in order for the United States to be globally competitive, its postsecondary schools need to produce more scientists and engineers.

**Purpose**

The purpose of this study is to analyze the effects of the curriculum on interest in, and attitudes toward, science. This study further investigates whether gender, grade level, or ethnicity has an effect on high school students' attitudes and interests towards science. Three research questions were developed to analyze whether those factors made a difference in how students answered the questions on the survey.

**Research Questions**

*Research Question 1.* Is there any difference for attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science based on grade level and whether or not students were enrolled in the NXT Robotics elective class?

(*Attitude of Science Inquiry*)

$Ho1_1$: There is no difference in the attitude of science inquiry means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_2$: There are no differences in the attitude of science inquiry means among students in the grade levels.

(*Enjoyment of Science Lessons*)

$Ho1_4$: There is no difference in the enjoyment of science lessons means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_5$: There are no differences in the enjoyment of science lessons gain score means among students in the grade levels.

(*Leisure Interest in Science*)

$Ho1_7$: There is no difference in the leisure interest in science means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_8$: There are no differences in the leisure interest in science means among students in the grade levels.

(*Career Interest in Science*)

$Ho1_{10}$: There is no difference in the career interest in science means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_{11}$: There are no differences in the career interest in science means among students in the grade levels.

*Research Question 2.* Among students in the NXT Robotics elective class (treatment group), is there a differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest based on gender?

$Ho2_1$: Among students in the treatment group, there is no difference in the attitude of science inquiry means between male and female students.

$Ho2_2$: Among students in the treatment group, there is no difference in the enjoyment of science lessons means between male and female students.

$Ho2_3$: Among students in the treatment group, there is no difference in the leisure interest in science means between male and female students.

$Ho2_4$: Among students in the treatment group, there is no difference in the career interest in science means between male and female students.

*Research Question 3.* Among students in the NXT Robotics elective class (treatment group), is there a differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest based on ethnicity?

$Ho3_1$: Among students in the treatment group, there are no differences in the attitude of science inquiry means among ethnic groups.

$Ho3_2$: Among students in the treatment group, there are no differences in the enjoyment of science lessons means among ethnic groups.

$Ho3_3$: Among students in the treatment group, there are no differences in the leisure interest in science means among ethnic groups.

$Ho3_4$: Among students in the treatment group, there are no differences in the career interest in science means among ethnic groups.

**Definition of Terms**

**Attitude of Science Inquiry**--measures attitude towards scientific experimentation and inquiry as ways of obtaining information about the world (Fraser, 1978).

**Career Interest in Science**-- measures the development of interest in pursuing a career in science (Fraser, 1978).

**Constructivism**--a theory of learning and change that implies that learning is a process in which new meaning is created by learning within the current knowledge (Papert & Harel, 1991).

**Enjoyment of Science Lessons**--measures the enjoyment of the science learning experience (Fraser, 1978).

**Ethnicity**--identifies a social group of people whose defining traits could be physiological, heritage, culture, language, or nationality (Smith, Walker, Fields, Brookins, & Seay, 1999).

**High-Stakes Testing**--refers to “the use of standardized testing measures as criteria for determining the quality of schools” (Gunzenhauser, 2003, p. 53). According to Gunzenhauser (2002), the No Child Left Behind Act of 2001 “expanded the role of high-stakes testing by legislating their incorporation in states’ school accountability programs” (p. 23).

**<u>Leisure Interest in Science</u>**--measures the development of interest in science and science-related activities (Fraser, 1978).

**<u>NXT Lego Mindstorm</u>**--the "Brick" robot that is used by the students in the robotics Class (LEGO Education, 2006).

**<u>Robot</u>**--a machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer (Oxford Dictionary, 2007). A robot is any machine that senses and gathers information from its environment and then uses this information to perform a task on its own (Allen, 2008).

**<u>STEM</u>**--Acronym for "science, technology, engineering, and mathematics." STEM is an integrative approach to teaching and learning that draws on the foundation of each individual field to form a cohesive course of instruction (National Science Board, 2004).

**<u>Test of Science-Related Attitude (TOSRA)</u>**--pretest and posttest used in the study. It was designed to test middle and high school students' progress in achieving attitudinal changes in science (Fraser, 1978).

**Summary**

The world is changing rapidly on a technological and scientific level. In every way the world, through globalization and the spread of free-market economies, is more interconnected than ever. This problem is compounded by the reality that our students are no longer competing only against each other; in this "new" global society, our students are also competing against their international peers. Most American students are not performing at a level deemed proficient in science on the National Assessment of Education Progress (NAEP) test (National Science Teacher Association, 2010). Only one in five high school seniors scored at least proficient on the NEAP, and only 34% of fourth graders and 30% of eighth graders were deemed proficient or better in science on the 2009 National Assessment of Educational Progress, known as the nation's report card (National Science Teacher Association, 2010). In science, the United State score on the Program for International Student Assessment (PISA) fell short of the averages posted by more than a dozen participating nations, including South Korea, Canada, Germany, and the United Kingdom (National Science Teacher Association, 2010). The NAEP data also found persistent achievement gaps among students in the United States based on race, ethnicity, and income level (National Science Teacher Association, 2010). This was evident at all three grade levels tested: 4th, 8th, and 12th.

One of the innovative programs working towards stopping this is the NXT Robotics program. Elliott (2007) stated, "If you're a K-12 teacher, the workforce that you're influencing is one that will exist several decades into the future, not the one that exists now. You need to shift your focus into the future" (as cited in Cech, 2007, p.3).

## Chapter Two: Literature Review

### Introduction

In an effort to increase hands-on science creativity for high schools students, a rural school division implemented an elective NXT Robotics class for students in grades 9 through 12 in the Career and Technical Education Department. Students' incorporate science, technology, engineering and mathematics lessons into their daily schedule through this class. This study employed a survey research approach and compared the attitudes and interests in science of students that completed a specialized NXT Robotics elective class versus those of students who did not take the NXT Robotics elective. In addition, an analysis of literature was conducted to further explore the affiliation of the effects of high-stakes testing in schools.

Literature related to a semester-long high school elective robotics class incorporating the NXT Mindstorm Robot into the curriculum is limited. The following topics supporting the development of an NXT Robotics high school elective class were identified for this study: constructivism approach to education, high-stakes testing, differentiation of instruction, and curriculum development. Robots created with LEGO® MINDSTORMS® NXT are actually very similar to robots used in the real world. Robots are used extensively to build automobiles, airplanes, ships, and unmanned vehicles that can be used to explore difficult and dangerous environments, such as the ocean floor or caves. Real-world robots not only have a central computer, motors, and sensors, and a communication tool to talk with other devices, much like the NXT robots, but they also are controlled using programming software (LEGO Education, 2010).

**Historical Background**

The NXT Robotics class was implemented to foster students' interest in science, technology, engineering and mathematics education with the aid of teacher support. Most secondary teachers do not have a degree in engineering, so they shy away from exposing their students to the subject, even though it is a way to incorporate math, science, and technology into the classroom (Jawaharial et al., 2007). Linda Katehi 2009, chancellor of the University of California, chaired a committee that found that problem solving, systems thinking, and teamwork aspects of engineering can benefit all students whether or not they ever pursue an engineering career.

The engineering behind the NXT Robolab was created through cooperation with LEGO Education and Tufts University. The director of the Center for Engineering Education Outreach (CEEO) at Tufts University worked with other engineers to create the NXT Robolab icon-based software. Engineers at Massachusetts Institute of Technology created the microprocessor for the program (American Society of Engineering Education PRISM, 2006). The software and microprocessor is the NXT Lego Mindstorm Robot Brick that LEGO Education has marketed for sale to the public. Rogers (2006), said, "It is great because LEGO is so well known, kids love it and the robotic side makes it come alive" (as cited in ASEE PRISM, 2006). As of fall 2006, Robolab has been implemented in about 35,000 schools worldwide and translated into 16 languages (Center for Engineering Education Outreach, 2010).

The newest software product being used in the NXT Robotics elective was developed in 2006 by National Instrument and called Mindstorm NXT. It is compatible with Robolab. LEGO NXT Mindstorm software is an optimized version of the professional NI LabVIEW graphical programming software used by scientists and engineers worldwide to design, control, and test consumer products and systems such as MP3 and DVD players, cell phones, and vehicle air bag safety systems (LEGO Education, 2010).

The main purpose of implementing an elective robotics class on the secondary level was to provide the students with a class that enabled them to use science, mathematics, and technology. The program was conceived to boost students' interests in math and science and demonstrate that a multi-disciplinary curriculum could affectively engage students. Kamen (2009), who cited Jawaharial et al. (2007) and Education Commission of the States (2004), noted that research indicates the choice of engineering as a career is often made as early as middle school, which means that students behind in math and lacking in science and technology at middle school level perform poorly in high school and are unlikely to choose careers in engineering and science (CEEO, 2009; CTE's Role in Science, Technology, Engineering and Math, 2009). Education Commission of the States (2004) reported that 81% of 4-year colleges in the United States offer remedial courses and 30% of incoming freshmen require remediation in writing, science, and mathematics. At least part of the reason so many postsecondary students need remedial education is because they are not exposed to a high enough level of math and science at the secondary level (National Science Foundation, 2009).

The Academy of Science (2009), like the National Science Foundation (2009) report, called for improvement in K-12 science and mathematics education; it lists the declining rate of innovation in the United States and the increase in outsourcing of information technology jobs to other countries as reasons for concern regarding the inadequate size of the nation's developed talent pool in the areas of math, science, and engineering.

Losen and Wald said that nationally, only about 62% of all students who enter 9$^{th}$ grade will graduate "on time" with a regular diploma in 12$^{th}$ grade (as cited in Jawaharial et al., 2007).

They went on to state that, while the graduation rate for White students is 75%, only approximately half of Black, Latino, and Native American students earn regular diplomas. Graduation rates are even lower for Black, Latino, and Native American males. The school division in which the study was conducted was 48% White, 51% Black, and 1% Latino; the demographics for the school division were also analyzed (County Public Schools, 2010).

For the last 20 years, the FIRST Robotics program has exposed middle and high school students to the sciences. Goodman Research Group reported that it had challenged them to think beyond the basic standardized tests and played a vital role in the education of students who wished to pursue careers in science, technology, mathematics, and engineering (as cited in U.S. FIRST, 2009). The number of students that the FIRST program can accommodate at any school is limited to individual resources. The LEGO NXT Mindstorm Robotics class was implemented into the secondary schools' program of studies in two rural high schools in Virginia to reach students that were interested in pursuing a hands-on science, mathematics, and technology class.

Richard Stephens (2010), chairman of Aerospace Industries, testified before the House Science and Technology Committee, stating that the following three key actions were necessary to ensure that the United States had enough scientists and engineers to meet future needs: to successfully graduate those who enter colleges and universities; to ensure enough qualified secondary teachers for science, math, and technology; and to motivate students to pursue STEM-related careers. According to the United States Department of Education (2009), 58 % of middle school math teachers and 68 % of middle school science teachers were not proficient or certified in these subjects. Stephens (2010), who cited National Science Foundation (1999), reported that math and science are hierarchical learning processes learned step by step and built upon what is already known; each requires success at one step before moving on to the next step. Statistics obtained from the United States Department of Education (2009) indicated that of the nearly 4,000,000 children who start pre-school each year, only about 25% of them go on to complete basic algebra in middle school, only about 20% are still interested in STEM subjects by the 8th grade, only 16% are still interested in STEM subjects by the 12th grade, only 9% declare a STEM major at the undergraduate level, only 4.5% actually graduate with a STEM-related degree, and only 1.7% graduate with an engineering degree (Stephens, 2010; United States Department of Education, 2009).

**Theoretical Background/Theoretical Framework**

*Constructivism.*

The philosophical approach to the NXT Robotics class is related to the constructivist education theory of John Dewey and the constructivism theory of Jean Piaget and Seymour Papert. Dethlefs (2002) reported that several published studies have demonstrated that constructivist learning classrooms have a positive effect on individual student achievement. Constructive investigations and peer collaboration are important parts of project-based learning, such as the NXT Robotics class. According to Liu and Hsiao, the constructivist theory of Dewey has provided a direction for the classroom teacher to implement project-based learning (as cited in Gregory & Hammerman, 2008).

John Dewey stated that the major purpose of education is learning to think (as cited in Nummedal, 1986). Genalo, Schmidt, and Schiltz, stated that during the Progressive movement of the 20th century, Dewey appealed to educators to provide instruction through investigation, inquiry, acquired knowledge, and the use of constructive imagination (as cited in Genalo et al. 2004). Ornstein stated that for students to grasp what is being taught, they needed to be able to relate it to real life experiences (as cited in Gregory & Hammerman, 2008).

Kafai and Resnick and Papert and Harel , stated that Piaget studied how children learn and develop through developmental psychology but that Piaget's theory of constructivism has been challenged over the years; even so, it still explains that children learn and construct their own knowledge (as cited in Genalo et al. 2004). Based on the work of Papert and Harel and Solomon, thought that constructivism provides an overall way to look at knowledge and that prior knowledge, new perceptions, and human goals are factors in creating new and individual knowledge (as cited in Genalo et al., 2004). Students build new knowledge from pre-existing knowledge or schemas. Mahoney (2009), stated that Piaget went on to study and explain how a child's development is influenced by the way that he or she understands and responds to physical experiences encountered in the environment and how they will become more complex as the child develops.

Genalo and Solomon, explained that Piaget's last stage of child development called *formal operations* is the stage when a child will be able to logically solve problems without having concrete objects to help (as cited in Mahoney, 2009). Students in this stage learn how to connect the different schemas and develop their own thinking. Mahoney (2009) went on to point out that Piaget believed that children must be able to construct their own knowledge and that they would go through a state of confusion and unbalance when presented with new knowledge but would make connections to prior knowledge and create an equilibrium, which would lead to more complex schemas. The theory encourages having children be more active in their learning and gives them the opportunity to experience learning through hand-on activities instead of as passive recipients of knowledge. The hands-on learning opportunities that an NXT Robotics class provides are as essential and necessary at the secondary education level as they are on the elementary education level because the class gives students the chance to apply what they have been taught in other core classes.

Having meaningful, relevant hands-on activities is a challenge for teachers. According to Papert and Harel, teachers are under so much pressure to make sure that students pass the required standardized tests that if those teachers find something that works for their classroom, they do not normally deviate from it (as cited in Mahoney, 2009). Papert, co-founder of MIT Artificial Intelligence and Media Labs, spent 4 years working for Piaget studying how children think. According to Rogers (2006), Papert believed that providing children with the opportunity to play with a problem would enhance their intellectual abilities and processes to solve a problem. Rogers (2006) also said that students' ability to relate their educational experiences to real life illustrates Piaget's principles, such as child-centered and constructivist approaches to learning.

A combination of Piaget's theory of learning development and Papert's theory of educational philosophy is referred to as constructionism and is used in the NXT Mindstorm robotics class. According to Akinoglu and Tandogan (2007) and Harmer and Cates (2007), research has found that students who have been taught using a constructivist teaching approach have shown increasingly positive attitudes toward science, regardless of their ethnicity. Students who like science felt more confident about learning different science content and increased their interest in science-related activities (Ornstein, 2006). A Harmer and Cates study (2007) showed that students of all ethnicities had an increase in interest in science, which led to the students being interested in learning science content outside the classroom setting. Papert (1991) stated that there was no easy definition of constructionism because it is multifaceted; it is just a sense of knowing that everything can be understood by being constructed. According to Welch (2007), Piaget and Papert have done extensive research and come to the conclusion that students need to be placed in stimulating and active learning environments to explore, discover, and rediscover solutions to problems.

Following the research of Piaget and Papert, the NXT Robotics class is a student centered, hands-on approach to science, technology, engineering, and mathematics. When learning how to program the robot with the computer, students are given a task to complete, an example of another program, and the opportunity to develop their own program. There is more than one way to write a program to complete a pre-assigned task; students are not told which method to use. The students know what task the robot is required to do, such as to move the red ball to another location, but they are not told how to accomplish this task. The students upload their program onto the robot and observe what the robot does; they then make revisions to the program until the program task is completed correctly. Revisions can be frustrating to the students, but they build on their prior knowledge until they are successful, and then they move on to the next phase of robot design.

The Mindstorm product line that is used in the NXT Robotics class is named after the book *Mindstorms* by Dr. Seymour Papert. The use of LEGO construction kits such as the NXT Mindstorm robot gives the students the opportunity to design, build, and program their own robot then use what worked and change what did not. Rogers (2006) said the students can change their approach to building and programming the robot and keep making revisions until they are able to develop the final version of their creation; if they can imagine it they can build it.

*High-stakes Testing.*

Students who attend secondary schools are impacted by high-stakes testing because core teachers place their primary focus on standardized testing (Sloanne & Kelly, 2003). A percentage of the students are required to pass state-mandated tests in the core areas of science, mathematics, language arts, and social studies. The percentage of students who are required to pass the core tests has steadily risen year to year with the ultimate goal of 100% passing rate in 2014 (Linn, Baker, & Betebenner, 2002). In 2001, the federal government enacted an educational initiative called the No Child Left Behind Act (NCLB). The bill implemented state-regulated tests to monitor student productivity on mandated tests.

Sunderman, Tracey, Kim, and Orfield, (2004) said NCLB has led individual states to develop high-stakes tests that can have serious sanctions for underperforming schools or can reward schools based on student performance on the tests. Taylor, Shepard, Kinner, and Rosenthal (2003) said that, while some feel sanctions or rewards promote quality teaching and encourage higher student achievement, others feel that high-stakes testing limits the scope of classroom instruction and student learning in undesirable ways. Thurlow and Johnson (2005) and Bottoms and Anthony (2005) said the introduction of high-stakes test accountability has changed the way that teachers teach their students. Through the high pressure of standardized testing, school divisions encourage teachers to teach a narrow subset of skills that will increase test performance rather than focus on deeper understanding that can readily be transferred to similar problems (Bottoms & Anthony, 2005; International Reading Association, 2009). This type of teaching does not give the students the opportunity to learn through exploration of a subject such as science (International Reading Association, 2009).

According to Thurlow and Johnson (2005), in an ideal school, assessment results should be designed not only to measure progress, but also to impact the content of the curriculum through use of instructional and intervention strategies that improve the learning of all students. The argument is that teachers focus more on test-taking skills than general and in-depth curriculum in their core subject. Thurlow and Johnson (2005) said that high-stakes testing emphasizes minimal competency for students and results in educators teaching directly to the minimal competencies rather than in-depth curriculum. Research conducted by Sunderman, Tracey, Kim, and Orfield (2004) for the Civil Rights Project at Harvard University on NCLB confirmed that:

> The NCLB accountability system is influencing the instructional and curricular practices of teachers, but it is producing unintended and possibly negative consequences. Teachers reported that, in response to NCLB accountability, they ignored important aspects of the curriculum, de-emphasized or neglected untested topics, and focused instruction on the tested subjects, probably excessively (p. 24).

Thurlow and Johnson (2005) said that when a teacher narrows his/her focus of teaching to make sure all the students pass the required standardized tests, it is colloquially referred to as "teaching to the test." High-stakes assessment refers to state and district competency exams administered to students as a sole measure employed to make critical decisions regarding the students, teachers, and/or schools, regardless of prior or future performance (Heubert & Hauser, 1999). According to Thurlow and Johnson (2005), high-stakes assessment is further defined as testing used as a sole measure to determine grade retention, promotion, diplomas/completion, and certification. Alignment between curriculum, assessment, and standards provides students with opportunities to demonstrate what they have learned (Ysseldyke, Dennison & Nelson, 2003). Alignment with standards also promotes the validity of results, prevents large test failure rates, and redirects teacher efforts away from teaching to the test (Ysseldyke et al., 2004).

The mandated tests in Virginia, Standards of Learning (SOL), are given to all the students in a particular grade and core subject, such as math, reading, social studies, and science. The SOL tests are criterion-referenced tests designed to measure whether students have mastered the specific content laid out in the state curriculum (Sullivan, 2006). The tests are short and consist entirely of multiple-choice questions in all subject areas except English (Sullivan, 2006). Sullivan (2006) said research shows that in addition to the teachers modifying their classroom curriculum and instruction to include the content of what is tested, teachers also tend to model the pedagogical approach represented by the test; thus, they use multiple choice worksheets and tests. The American Educational Research Association (1999) surveyed 722 Virginia teachers, and more than 80% indicated that the Virginia's high-stakes SOL test had impacted how they presented the curriculum for their subjects (Virginia Commonwealth University, 2001). Results showed the teachers focused their daily lessons towards test-taking requirements. Moon, Brighton and Callahan (2003) surveyed Virginia teachers and concluded that content delivered to students was directly affected by high-stakes testing, and subjects not tested were given less instruction time in order to create a larger block of time for instruction for tested subjects and skills.

According to a survey of California, Texas, and Virginia teachers, "content delivered to students also seems to be directly affected by the state testing pressure" (Moon, Brighton, & Callahan, 2003, p.23). A criticism of high-stakes testing is that the emphasis on minimal competency levels for students results in schools teaching directly to these minimal competencies rather than the broader curriculum (Sloane & Kelly, 2003). On the opposing side, supporters of test-based accountability state that teachers concentrate on broad areas of knowledge and skills measured by the test instead of content specific to the test question (Abrams & Madaus, 2003).

Thurlow and Johnson (2005) said that while high-stakes assessment is used extensively in all schools, it does have its limitations; teachers do not have the time to teach a particular subject in depth because of the large amount of curriculum that needs to be covered. According to Thurlow and Johnson (2005), some concerns of high-stakes testing are that too much emphasis on test scores fails to reflect true changes in student achievement, narrows curriculum that is covered, and uses too much class time to prepare students to take the test. Ysseldyke et al. (2003) said a focus on the test rather than the subject also means that what gets tested gets taught, and what does not get tested may get less attention or may not be taught at all. Ysseldyke et al. (2003) also said that high-stakes testing drives instruction; students are not given the leeway to explore and learn, but instead their core curriculum is focused almost entirely on the material that they will be tested on at the end of the school year. W. P. Quigley, in a case before the Supreme Court of Louisiana, *Due process rights of grade school students subjected to high-stakes testing,* (2001) stated the following:

> There are many opponents of high-stakes testing who advance compelling arguments against this movement. Opponents believe high-stakes exams place a singular emphasis on a test grade, force teachers to teach to a test ultimately pulling them away from teaching higher level thinking and problem-solving skills, and are a misrepresentation of actual student achievement. (p.28)

Teachers in high-stakes testing situations feel more pressure to have their students perform well, and therefore, more closely align their teaching with the test (Berube, 2004). Teachers have confirmed that the NCLB accountability system is influencing the instructional and curriculum practices of teachers, but it is producing unintended and possibly negative consequences (Sunderman, 2004). They have reported neglecting untested topics and focusing instruction on the tested subjects, probably excessively (Sunderman, 2004). Stressful environments can reduce the students' ability to learn while a stimulating environment promotes neuron connections in the brain, which may be a contributing factor for an enhanced learning capacity (Jensen, 1998). Diamond and Hobson (1998) described an enriched environment from learning as one that provides positive emotional support free of stress and pressure, allows for social interaction between students and teacher, and presents opportunity for active participation in appropriately challenging activities. A teacher can create a classroom climate that includes all learners, embraces students' hopes and aspirations, and provides an enriched environment for authentic learning (Givens, 2002).

*NXT Robotics Program.*

The NXT Robotics class was designed to give students the opportunity to apply what they have learned in their mathematics, technology, and science classes. The NXT Robotics class was incorporated into the Career and Technology Education program (CTE) because of required certifications of the teachers. This was done to assure approval by the Virginia Department of Education (DOE). The course is listed under Robotics Workcell Technology I (8557) and has a limit of 20 students in the class because of a Carl Perkins grant that the school division receives every year. The class description for the DOE is as follows: "This course provides instruction in basic computer programming, electronics, motor control, and feed back systems used in assembly and manufacturing settings. In addition, students learn how to program microcontroller for robotics manipulation" (Career and Technology Education, 2010).

The instructional framework for the competency-based CTE course Robotics Workcell Technology (8557) is designed for use by teachers to help students achieve the validated, specific tasks and/or competencies considered essential for working in the occupations of science, technology, engineering, and mathematics (CTE Resource Center, 2010). The application and assessment of the robotic program is through demonstration of knowledge by the students. The students are assigned a task to complete; for example, they would be told that the robot has to move a small red Lego block from one location and deposit it in a box at another location. The students then work the situation backwards; they know what has to be accomplished, and they now have to figure out how to accomplish it. They know the final outcome of the assignment and have a rubric that informs them of how many points they receive for each of the steps they complete correctly. The students have to figure out the dimensions to which they need to build the robot to accomplish the task assigned. They need to measure the distance the robot has to travel; the speed the robot needs to travel by a set time; and appendages that need to be built onto the robot to either pick up, push, or pull the small red Lego block to its final location. The students then decide how the robot is going to get the red Lego block into the box and make sure they build appendages onto the robot to accomplish this task. All students have their own NXT Robotic Mindstorm kit and will build their own robot to suit the needs and goals of the task at hand.

Students are given the chance to interact with other students in the class, with the teacher, and through online blogs. The average 20-student class will have three special education students, five gifted students, and 12 students of average intelligence. Students can work together in teams of two or more students or individually if they prefer. The main focus of the classroom teacher in the NXT Robotics elective is to be a facilitator of the class. Teachers do not have to align their teaching to get the students to pass a state-mandated test. Students apply their skills and knowledge in a way that gives them the freedom to explore and become innovators in education. In the NXT Robotics program, teachers do have an accountability system in place on what needs to be taught: computer programming, robotic sensor usage, and gracious professionalism. The curriculum in the NXT Robotics elective is computer based, so students can be assessed at different learning levels and do not have to learn the same thing at the same time as all the other students in the class. Students that already have knowledge of robotics will be able to learn at a different level than a student that is just acquiring the technological skills of robotics.

The NXT Robotics class is taught through differentiation of instruction; this involves providing students with individual lessons to acquire content knowledge. The teacher develops lessons so that all the students in the classroom can learn effectively, regardless of prior knowledge level (Gregory & Hammerson, 2008; Tomlinson, 2006). Differentiation of instruction ensures that what students learn, how they learn it, and how they demonstrate what they have learned are all matched to the students' readiness level (Gregory & Hammerson, 2008; Tomlinson, 2006). The robotics class is modeled after a student-centered inquiry-based science class using differentiation of instruction. Courses steeped in expository methods do not promote the development of critical and creative thinking, problem solving, and decision making (Gregory & Hammerman, 2008). More recently, brain research, advancements in technology, awareness of differences in learning styles, and theories related to intelligence have focused on the importance of providing varied pathways to learning and making science relevant by applying it to the lives of students and the technological world in which they live (Gregory & Hammerman, 2008).

Differentiation of instruction is used in the robotics class to ensure that all students are learning on their level and according to their interests. Teaching students to be prepared to adapt to change in science and technology needs to be a priority in secondary education. The goals of the NXT Robotics class can be achieved through careful planning of instruction that is aligned and facilitated by teachers who have acquired the skills through staff development concentrating on knowledge, flexibility, and the interests of students at diverse learning levels (American Association for the Advancement of Science, 2004; Kazmierczak & James, 2005).

Using LEGO Mindstorm NXT robotics kits along with supplemental LEGO kits, the teachers develop a custom curriculum to fit the needs of each individual student in the classroom. This enables each student to receive differential lessons where they progress from their level of comfort when working with the robots to expertise in robot programming and design. Students are given the opportunity to advance their skills in math, science, and technology at their own pace. Teachers are able to accommodate the specific needs and challenges associated with working with a wide variety of student learning levels in grades 9 through 12. Selecting a variety of appropriate methods and strategies for student engagement and success is the key to promoting student achievement (Bottoms & Anthony, 2005; Gregory & Hammerman, 2008). Flexibility throughout the instruction process is critical as assessment of student progress may require changes, modifications, or additions to the original plan (Bottoms & Anthony, 2005; Gregory & Hammerman, 2008). The teachers will determine how the NXT Robotics program is integrated into their classroom, with guidance from the science coordinator. Teachers will develop and assign weekly projects to the students according to their level of expertise.

The LEGO Mindstorm NXT robots allowed all students to have their own robot and create an autonomous electromechanical invention that they could build on and program. For this study each robot brick had four inputs and three outputs systems to program: motors, light sensors, sound sensors, touch sensors, color sensors, temperature sensors, and ultrasonic sensors. The curriculum used for the program was developed by Carnegie-Mellon’s Robotics Academy: Robotics Engineering volume I and II, and Science and Data Logging. The computer software program used for the study, NXT 2.0 Programming, was developed in conjunction with National Instruments and The LEGO Group.

The robotics teachers used a planning guide for incorporating differentiated instruction. Shown in Table 1, are the eight phases that each complete lesson should consist of with ideas on how to accomplish the task. Phase 1 of the complete lesson plan was content standards, and the teachers could accomplish this task by considering the STEM area standards. Phase two of the complete lesson plan was to explore the concepts, skills, and disposition of the lesson, and teachers would review content and identify the concepts of the lesson. In phase three of the complete lesson plan, the teachers would pre-assess the students and then consider a variety of learning approaches. In phase four of the lesson planning, the teachers would activate and engage the students through different media, such as demonstrations, videos, questions, and displays. The teachers in phase five would then have the students investigate through inquiry, and the students would have constructed inquires, problem-based learning through projects and products. During phase six of the complete lesson plan, the students would link new learning to prior knowledge through questions and discussions to reflect on process and data. In phase seven the students would ask and research new questions and construct inquires based on the questions. In the last phase, eight, the teacher would assess and evaluate the students; this could be done through a variety of methods, including rubrics, notebook entries, explanations, interviews, or performance tasks.

The phases of the model are consistent with models for high quality of instruction (Gregory & Chapman, 2007; Gregory & Hammerman, 2008). The planning guide also has a section that provides resources and strategies for differentiating instruction. The lesson plans are constructed to use a variety of strategies to engage the different grade levels in the class. The lessons also need to be flexible, so a student who is more advanced in one topic and less advanced in another topic can move smoothly between the levels of learning. In a robotics class there are also numerous teachable moments that occur among the students and the teacher needs to be flexible enough to let this type of learning occur unhindered. Students need to construct their knowledge through inquiry-based lessons (Bottoms & Anthony, 2005; Gregory & Hammerman, 2008). Embedding teaching strategies within an inquiry-based pedagogy can be an effective way to boost performance in academics, critical thinking, and problem solving (Bottoms & Anthony, 2005; Gregory & Hammerman, 2008). Incorporating differentiation of instruction in the NXT Robotics class enabled the teacher to work with all students at their level of knowledge and comfort.

Table 1

*Planning Guide for Differentiated Instruction - Robotics in High School*

| | |
|---|---|
| **1. Content standards:**<br>What students should know and be able to do; Unifying concepts and processes in robotics | **Consider:**<br>Building upon STEM area standards (National Science Standards, Technological Literacy Standards, Career Cluster Standards, and National Mathematics Standards) |
| **2. Concepts, skills, and dispositions:**<br>Key concepts, process, and thinking skills; valued dispositions | **What teachers will do:**<br>Review content and identify concepts that address learning goals and essential questions on which to base activities and experiences |
| **3. Knowing the learner:**<br>Pre-assess; use data to inform methods; consider a variety of approaches to learning | **Consider:**<br>Multiple intelligences and learning profiles; interests; readiness, gender equity; multiculturalism |
| **4. Activate and engage:**<br>Create wonder; motivate; generate interest; use novelty; identify inquiry questions | **K-W-L:**<br>(What I Know – What I Want to Know – What I Want to Learn):<br>Demonstration; video clips; speakers; questions; displays |

| | |
|---|---|
| **5. Acquire and explore:** Investigate through inquiry, use varied methods and strategies; offer multiple pathways for learning based on students' needs, interests, and learning profiles | First-hand experiences; teacher and student-constructed inquires; problem-based learning; projects and products; demonstrations |
| **6. Explain and apply learning; create meaning:** Link new learning to prior knowledge; make connections; apply learning and create meaning | Use questions and discussions to reflect on process and data; analyze learning; apply content to technology, society, and lives of students |
| **7. Elaborate and extend:** Ask and research new questions; construct inquiries based on questions | Applications to community, state, national, global problems and issues; problem solving; inventions; Internet research |
| **8. Assess and evaluate:** Capture evidence of learning to monitor progress and guide instruction; provide opportunities for relearning | Use rubrics for self-assessments, notebook entries, explanations, interviews, teacher-made tests, performance tasks, projects and presentations that provide evidence of learning; portfolio entries show work and progress over time |

(Gregory & Hammerman, 2008)

In order to ensure sustainability of the NXT Robotics program, the secondary teachers attended professional development training and were supported through the science coordinator, so they could continue to grow academically and be able to conduct the program independently and cooperatively with the science, mathematics, and technology teachers in the school division. The curriculum for the NXT robotics class was chosen for its problem-based design and to enhance cross-curricular learning. Teachers were also enrolled in a class for six consecutive weeks, held once a week for two hours through the online robotics academy offered through Carnegie Mellon University. The class focused on how to program robots that use the NXT Robotics Brick. The web-based professional development course is STEM-focused and includes methodologies for pedagogy (Robotics Academy, 2010). The class stressed how to use robotics as an organizer to teach STEM concepts. The Robotics Academy courses are designed around

National Science Education (NSES) Standards, National Council of Teachers of Mathematics (NCTM) Standards, and International Technology Education Association (ITEA) Standards (Robotics Academy, 2010).

**Students' Attitudes in Science**

The term 'Attitude in Science' is a way of feeling about science. According to Zacharia and Barton (2004), a number of studies on students' attitudes toward science have been documented in the literature. While science educators believe that attitudes toward science play a significant role in students' learning process, the results, particularly of studies investigating the impact of this affective domain toward either students' achievement or their interest in science, have been inconclusive (Zacharia & Barton, 2004). Merriam-Webster defines attitude as "a: a mental position with regard to a fact or state, b: a feeling or emotion toward a fact or state" (2000). The National Science Board released a report in 2004 stating that research students who have a negative attitude towards science in school will probably lack basic scientific knowledge in later years. Data also indicate that interest in science and technology has declined between 1996 and 2002 (National Science Board, 2004).

Improving students' attitudes toward and interest in science is the first step in encouraging students to continue in the STEM fields beyond high school. Attitude towards science is most often affected by school atmosphere, level of aspiration, parental influence, and quality teaching methods (Papanastasiou & Papanastasiou, 2004). Greenfield said that younger students express more positive attitudes about science than older students do, and middle school students express significantly more negative attitudes than did elementary or high school students (as cited in Jarvis & Pell, 2002). Research conducted by Virginia Commonwealth University (2004) showed that 91% of the public agreed that it is very important or somewhat important for the global economy to encourage more students to have an understanding and working knowledge of science and technology in order to be successful in college.

The three common features of attitude are that attitude is learned, it influences actions, and it is consistent when in action whether it is positive or negative (Dethlefs, 2002; Schlechty, 2002). Eiser pointed out that the concept of attitude has been extensively studied over the years (as cited in Dethlefs, 2002; as cited in Schlechty, 2002). There is no one definition for attitude. Social scientists acknowledge that attitudinal behavior is learned and can be modified (Dethlefs, 2002). Because attitude can be modified, it is imperative that secondary schools work with all students to improve their overall attitude toward the sciences, regardless of gender and ethnicity, and to help them understand that science is useful and important.

Zacharia and Barton (2004) developed a detailed argument for why science needs to be more clearly defined in attitude instruments. Koballa suggested that attitudes can be changed, but such occurrences are not random (as cited in Zacharia & Barton, 2004). Something must happen to cause the change; students are not born liking or disliking science in school; they learn to like it or dislike it. Students that are motivated and interested in a subject use deeper cognitive processing, which results in better conceptual understanding and higher achievement (Dethlefs, 2002). Schlechty (2002) stated that "if students become engaged in the right stuff, they are likely to learn what we want them to learn" (p. 24). Student attitudes and interests have been linked to student achievement in school. The word *attitude* is used to mean students' intrinsic interest in a topic they are learning.

In this study the elective NXT robotics class is being evaluated for the students' attitude and interest in science. Haladyna and Shaughnessy (1983) mentioned that students' attitudes toward science are determined by three independent constructs: teacher, student, and learning environment. Gregory and Hammerson (2008) stated that students' personality and aptitude, regardless of their intelligence quotient, affected their attitude towards science. Parental involvement also plays a very important role in the development of science attitudes of students (George & Kaplan, 1998). George (2000) found in his study that students' attitudes toward science generally decline over the middle and high school years. Science self-concept has been found to be the strongest predictor of attitudes toward science. Teacher encouragement of science and peer attitudes is a significant predictor of students' attitudes. Males were found to have more positive initial attitudes toward science, but their attitudes worsened faster than those of females. George (2000) found that students in metropolitan and rural schools had less positive attitudes toward science than students in suburban schools.

Dethlefs (2002) conducted a research study on the relationship of constructivist learning environments to students' attitudes and achievement in high school mathematics and sciences. Findings in Dethlefs's study related to student attitudes are as follows:

- Constructivist learning environments are positively associated with student attitudes in high school biology and algebra.
- Students that had more control over their learning activities were associated with deeper cognitive processing strategies.
- Students' attitudes and intrinsic value were shown to determine students' future enrollment in elective classes.
- There was a relationship between cooperative group work and students' interest in school.

**The Test of Science-Related Attitude (TOSRA)**

The Test of Science-Related Attitude (TOSRA), developed by Fraser (1981), is a multidimensional instrument with a strong theoretical foundation. TOSRA was designed to be used by researchers to examine middle and high school students' progress in achieving attitudinal changes and is useful for examining the performance of groups or classes of students (Fraser, 1981). Fraser developed the TOSRA based on Klopfer's (1971) table of specifications of affective behaviors for scientific education, which used five classification scales. The final version of TOSRA measured seven distinct science-related attitudes among middle and high school students: social implications of science, normality of scientists, attitudes of science inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, and career interest in science (Fraser, 1981).

Cavallo and Laubach (2001), like Fisher & Waldrip (1999), conducted studies that showed the TOSRA could be scored by selected subscales of the original seven distinct science-related attitude subscales. For this study the researcher will examine four of the seven science-related attitudes: attitudes of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science. "Attitude of science inquiry" measures attitudes toward scientific experimentation and inquiry as ways of obtaining information about the world. "Enjoyment of science lessons" measures the enjoyment of the science learning experience. "Leisure interest in science" measures the development of interest in science and science-related activities. "Career interest in science" measures the development of interest in pursuing a career in science. The TOSRA allowed the researcher to obtain a profile of a group of students based on the scores in each of the four areas studied. TOSRA is deemed reliable because it has been capable of consistently producing results while controlling for random error (Ary, Jacobs, Razavieh, & Sorensen, 2006). Details on the validity and reliability of the TOSRA are provided in chapter 3 of this study.

*Gender, Grade Level, and Ethnicity.*

Freedman and Napier and Riley conducted research that determined that student attitude toward science has been shown to correlate with achievement in the science classroom (as cited in Osborne, Simon & Collins, 2003). Schibeci and Riley (1986) studied the relationship between students' perceptions, attitudes, background, and achievement. The study showed that gender is directly related to attitude and achievement. According to Jones, Howe, and Rua (2000), research has been conducted that shows that gender differences exist in attitudes toward science, but the process of how these attitudes affect science outcomes is unclear. Kanai and Norman (1997) cited Catsambis's study, which documented that as females grow older, they are less interested in science than are males. In a study conducted by Schibeci and Riley (1986), females scored lower in both attitude and achievement. In another study (Hill, Pettus, & Hedin, 1990), high school females were found to have a lack of interest in science-related activities and careers.

The National Science Foundation (2009) released a report indicating concern about female students and mathematics, because mathematics is considered to be the gateway to entering science, technology, engineering, and mathematics (STEM) fields and females are underrepresented in STEM careers. The results in the Trends in International Mathematics and Science Study (TIMSS) 2007 report indicated eighth-grade female mathematics scores to be significantly higher than those of males on average internationally. From the 49 countries that participated in TIMSS, females had statistically higher mathematics scores in 16 countries, and males had statistically higher mathematics scores in 7 countries (Mullis, Martin, & Foy, 2008).

In contrast the Bureau of Labor Statistics' study entitled Women in the Labor Force (2007) reported that only 14% of those working in architecture and engineering in the United States are women. Architecture and engineering fields require a strong science and mathematics background. The American Geologic Institute (2004) stated there is a gender disparity in STEM fields and that schools are failing to encourage and develop interest among females in mathematics and science. The United States Department of Education's Nation's Report Card for 2005 compared science scores from 1996 to 2005, finding that 4th-grade average science scores have risen slightly, 8th-grade scores are unchanged, and 12th-grade scores have declined (National Center for Educational Statistics, 2006). In the same report, elementary students showed a more positive attitude towards science and science teachers than middle and high school students.

The 2009 Program for International Student Assessment (PISA) report for science released December 2010 shows U.S. students have only average science literacy. PISA is an international assessment coordinated by the Organization of Economic Cooperation and Development (OECD) that compares the performance of 15-year-old students in reading, math, and science to their peers internationally. According to the PISA report for science, U.S. students have moved up to average in the rankings with students from around the world. The report showed U.S. students made an average score of 502, an increase from 486 in 2006. However, this rise only puts U.S. students in the middle of the pack, showing only average progress and behind several other countries, including Japan, Finland, and South Korea.

Although, the rise in scores shows some progress, education leaders are not celebrating. U.S. Secretary of Education Arne Duncan had this to say about the science scores: "I don't think that's much to celebrate.… Being average in science is a mantle of mediocrity" (Duncan, 2010, p.1). Dr. Francis Eberle, executive director of NSTA, released this statement (National Science Teacher Association, 2010) on the PISA report:

> The National Science Teachers Association is cautiously optimistic and somewhat surprised in the results for Science in the PISA Report. We are cautiously optimistic in that average science scores are up from 2006; however, this growth only puts the U.S. from the lower middle to the middle of the pack. We are still behind 18 countries and only 29% of students tested showed proficiency in science. We are surprised at the scores because a very limited investment has been made on a national level in training and retaining science teachers. We believe that test scores for our students could be significantly improved if schools, states, and the federal government would commit to a larger investment in science teaching and learning. As this report shows, our international neighbors are making the investment in science education. Our ability as a nation to remain competitive with other countries is dependent on how well we educate our children in science and mathematics. We hope this report will generate more public discussion about the need to make the necessary investments in science education. (p. 1)

In another study, females in science compared to females in other careers were significantly more likely to value mathematics and science for their future career goals. Males in science compared to males in other careers had significantly higher high school grade point averages in natural science and higher career aspirations in science (Farmer, Wardrop, & Rotella, 1999). In elementary school, about as many females as males have a positive attitude towards science; fully 66% of fourth-grade females and 68% of fourth-grade males reported they like science (National Center for Education Statistics, 2000). By eighth grade, more females turn away from STEM activities than males (Thom, 2001). Ware and Lee examined a nationally representative sample of high-ability students and found that females perceived a career in science as incompatible with their future (as cited in Thom, 2001).

The National Education Goals Report (1997) indicated that students in high school were less likely to have positive attitudes towards science and mathematics than students in lower grades. The gap between males and females increased substantially; in grade 4, 81% of males and 78% of females liked science; by grade 12, the percentage of males liking science had dropped to 74%, and the percentage for females had dropped to 57%. Out of the 1,100,000 high school seniors in the United States who took a college entrance exam in 2002, just under 6% indicated plans to pursue a degree in engineering, a nearly 33% decrease in interest from the previous decade (Tapping American's Potential, 2005). The National Science Foundation (2009) conducted a statistical study that showed females obtained more degrees in science and engineering than males between 1997 and 2006. The degrees obtained by females were primarily in the behavioral, social, and medical sciences. The males exhibited a dominant position in the majority of engineering and experimental sciences. Females make up 49% of the workforce but only 25% of the STEM workforce (Thom, 2001).

Ethnicity identifies a social group of people whose defining traits could be ones of physiology, heritage, culture, language, or nationality (Smith et al., 1999). These defining traits shape and develop one's individual identity. Contributing to this overall identity is the personal ethnic identity. Aboud and Doyle (1993) agreed that ethnic identity is a self-defined construct of one's ethnic group membership and the role this membership plays in one's thoughts, feelings, perceptions, preferences, and behaviors. Aboud and Doyle (1993) and Phinney (1993) stated that ethnicity provides a foundation for perspectives, which adolescents utilize for exploration and commitments to occupational, religious, political, and gender roles.

The term *majority* refers to a group that is larger than others in population size. For this study the White, non-Hispanic students are referred to as the majority ethnic group and Black, non-Hispanic, Hispanic, and Asian and Pacific Islander students are referred to as the minority ethnic groups. The National Assessment for Educational Progress (2009) reported that 38% of white fourth-grade males were proficient in reading compared to 12% of black fourth-grade males, whereas in eighth grade, 44% of white males and only 12% of black males were proficient in mathematics (Gabriel, 2010). The report also found that math scores in 2009 for black males were not much different than those for black females in grades 4 and 8, but black males were behind Hispanics of both genders (Gabriel, 2010). Steele's research indicated that although minority students began school with test scores similar to their majority peers, by middle school, many minority students had fallen two grade levels behind (as cited in Gabriel, 2010). By the end of high school, in fact, minority students had skills in both reading and mathematics that were the same as those of majority students in eighth grade (Gabriel, 2010).

There is a substantial difference between majority and minority students that has not changed over the decades at any grade (National Center for Education Statistics [NCES], 2003). Wyatt and Haycock are two of several authors that agree that the abundance of Black non-Hispanic and Hispanic males in special education, in remedial academic tracks, and with excessive disciplinary referrals can be attributed to the low academic expectations of teachers and administrators in public schools (as cited in Gabriel, 2010).

The Black non-Hispanic population makes up 10% of the labor force but less than 3% of scientists and engineers. The numbers are low for several reasons, but they all revolve around the same basic problem: preparation for most careers in science is best begun early, and most black children are not encouraged in these areas soon enough (Gabriel, 2010). According to

Cross and Slater, (2000), Black non-Hispanic males' underachievement in elementary and secondary school is limiting their opportunities to enter college. Black males who are high school graduates attend colleges at rates far below those for white male high school graduates. Because of this educational gap, black males are the lowest paid group and rated highest in unemployment (Gabriel, 2010). Poverty alone does not seem to explain the differences. Poor white males do just as well as black males who do not live in poverty, with poverty level being measured by whether the students qualify for subsidized school lunches (Gabriel, 2010). The National Assessment for Education Progress (NAEP) (2009) report showed that black males on average fall behind from their earliest years. Black mothers have a higher infant mortality rate, and black children are twice as likely as whites to live in a home where no parent has a job. In high school, black males drop out at nearly twice the rate of white males, and their SAT scores are on average 104 points lower; in college, black men represented just 5% of students in 2008 (Gabriel, 2010). The analysis of results on the NAEP tests found that math scores in 2009 for black males were not much different than those for black females in grades 4 and 8, but black boys lagged behind Hispanics of both sexes, and they fell behind white males by at least 30 points, a gap that is interpreted as three academic grades (Gabriel, 2010).

Carey (1995) also pointed out that the problem of Black non-Hispanic high school students not showing an interest in science as a course of study or as a potential career has a lot to do with low self-esteem as well as a lack of exposure to science from a Black non-Hispanic perspective. According to Cary (1995), most U.S. educators tend to have the opinion that culturally diverse students are deficient. Their remedy for this is to attempt to assimilate them by trying to fit them into the dominant cultural model.

Delpit (1992) suggested that educators examine the curriculum very closely to assess and correct inadequacies so that all students will be able to relate to the curriculum. Ford and Harris, said teachers who consider learning styles for designing lessons should be able to successfully motivate the Black non-Hispanic and Hispanic male learners (as cited in Carey, 1995; as cited in Gabriel, 2010). Many male students rely upon visual stimuli much more than auditory. The lecture method of teaching will not motivate these male students because they must have a lot of visual stimuli. Similarly, they are more tactile and kinesthetic. Teachers would do well to allow these students to work with their hands on projects and move about the room when learning (Addison & Westmoreland, 1999). Pang (1994) stated that many teachers do not realize that the learning environment is affected by culture that travels with the students from home. It is in the best interest of students for teachers to understand the strengths that culture gives to children. Teaching styles such as cooperative learning, whole-group mastery learning, and school-specific interventions that capitalize on cultural strengths should be initiated in schools with minority populations (Tatum, 1999). Addison and Westmoreland (1999) pointed out that minority children tend to use learning styles that are inconsistent with those of the majority culture.

Educational statistics in the United States show that minority populations are increasing among students and decreasing among teachers (Gabriel, 2010). As the nation’s student population becomes more culturally and linguistically diverse, science educators are increasingly aware of the need to address equity for these students (Lee, 2001). Boyd, Hunt, Kandell, and Lucas (2003) and Chavous et al., (2003) contended that when students are in an environment where their ethnicity is valued, supported, and recognized, it supports the development of a positive ethnic identity. This established sense of self allows students to approach academics with confidence and not question their performance as challenging their group identification.

Boyd et al. (2003) and Chavous et al. (2003) said students who develop an ethnic group affiliation consisting of pride, awareness of societal inequity, and a sense of membership perform better in the school setting because they have acknowledged differences, sought support, and draw on the collective strength of the group to overcome issues. Boyd et al. (2003) and Chavous, et al. (2003) also agreed that the sense of membership and belonging is a source of pride and connection to others of similar ethnicity and heritage, allowing for personal decisions about the role ethnic identity plays in their life regardless of the extent of their ethnic involvement.

**Summary**

Robotics is considered a multi-disciplinary field, which combines mechanical, electrical, electronics engineering, computer science, and logical skills. The advancement of technology and engineering has enabled the NXT robot to be used in the schools where anybody can build onto the basic structure (block) and program and run their own robots. According to Jawaharial et al. (2007) and Kazmierczak and James (2005), experiences indicate that learners who are immersed in the activity, acquire important skills in math and science without realizing that they are intensively engaged in the learning process. Science engages students and activates the brain through emotion, excitement, motion, challenge, thought, reflection, and concept development (Jawaharial, et al., 2007; Kazmierczak & James, 2005). The classroom climate, as well as the instructional practices that are used, ultimately affects the way students are motivated to learn, acquire knowledge, construct knowledge, and develop skills and attitudes (Gregory & Hammerman, 2008). Negative emotions and social interactions can inhibit academic progress (Jawaharial et al., 2007; Kazmierczak & James, 2005). According to Gregory and Hammerman (2008), students will spend an inordinate amount of attention and energy protecting themselves from ridicule and rejection rather than learning new knowledge and skills. Students need to feel safe and secure as they engage in challenging and meaningful learning experiences. An environment that embraces diversity, eliminates threat, and provides support and encouragement enables students to focus attention on learning.

In the words of Barack Obama (2009), "Science is more essential for our prosperity, our security, our health, our environment, and our quality of life than it has ever been before" (p.1), yet even with the importance of science backed by the President of the United States, NCLB continues to be policy, and with it comes a collective stifling of an entire generation of inquisitive scientific minds (Stephens, 2010). NCLB does mandate that students must be assessed in science at least once in grades 10-12. However, unlike the situation in math and reading, there are no federal consequences if the students do not pass the test. Jawaharial et al. (2007) reported that this has resulted in the sciences being pushed to the back on funding by many school divisions while the need for highly trained college-educated scientists in the work force continues to increase. The inquisitive scientific minds of young people need to be nurtured to ensure that important science-based industries in this country flourish; the two are inextricably connected.

The NXT Robotics program makes science accessible to students with varied levels of knowledge by making the program adaptable to each individual student. It appeals directly to a generation of children raised on advanced technology. The idea that there was a time when computers, cell phones, and MP3 players did not exist is vaguely foreign to this generation. As a consequence, the teaching style in U.S. schools needs to adapt to the learning styles and environments to which these children have grown accustomed. The NXT Robotics program allows students to learn for themselves and solve their own problems, building the students' confidence and sense of accomplishment (Rogers, 2006). It teaches the students important lessons about failure, success, and perseverance--important life lessons that cannot be learned from a multiple-choice test. The class also encourages students' interest in science by actively demonstrating the impact that science can have on everyday life (Rogers, 2006). The NXT Robotics program takes the information written in a standard textbook and makes it relevant to the students, so students can no longer complain about school subjects being irrelevant to their lives (Rogers, 2006).

# Chapter Three: Methodology

This chapter includes a description of the research context, the research study participants, and the instrument used to collect the data. The procedures used in the research design will also be covered, along with the data analysis techniques chosen to answer the three research questions. Finally, the chapter will include a description of the research design.

## Introduction

A quasi-experimental research design was employed in the evaluation of the educational program, the NXT Robotics class. This program was evaluated by comparing the attitudes and interests of students who participated in the NXT Robotics class and not the science class (treatment group) and students who participated in the science class and not the NXT Robotics class (control group) (Ary, Jacobs, Razavieh, & Sorensen, 2006). A pretest and posttest non-equivalent group design (NEGD) was used in this study. While a treatment group and a control group were compared, the groups were intact groups chosen out of convenience rather than through random assignment into the treatment and control groups (Heffner, 1999; Trochim, 2006). According to Glatthorn and Joyner (2005), quasi-experimental research is a form of quantitative research that includes making judgments about the merit or worth of an educational program like the NXT Robotics class. I am aware of the limitations in a quasi-experimental research design that consisted of selection bias of the treatment and control groups (Ary et. al., 2006).

## The Research Context

This study was conducted in a rural school division. For the purpose of confidentiality, the high schools will be referred to as High School A and High School B. High School A's demographics are 48% White, non-Hispanic; 51% Black, non-Hispanic; and 1% Hispanic and Asian-Pacific Islander. This high school offered one elective NXT Robotics class with a maximum of 20 students each during the first and second semesters, for 18 weeks, during the 2009-2010 school year. High School A is located 20 miles from the closest city and on a sports lake. Businesses in the city consist of family restaurants, one fast food restaurant, small gift shops, small family businesses, two hotels, one grocery store, two gas stations, and a marina.

High School B's demographics are 50% White, non-Hispanic; 49% Black, non-Hispanic; and 1% Hispanic and Asian-Pacific Islander. This high school offered two elective NXT Robotics classes each semester with a maximum of 20 students each during the first and second semesters, for 18 weeks, during the 2009-2010 school year. High School B is located one mile from the closest city, where businesses consist of numerous family restaurants, 10 fast food restaurants, three grocery stores, a community college, and eight gas stations.

**Study Participants**

In the study that was completed in spring 2010, there were 57 students enrolled in the elective NXT Robotics class but not in a core science class (treatment group) and 57 students enrolled in core science classes but not enrolled in the elective NXT Robotics class (control group). Of the 114 students in the study, 96 (84.2%) were male, while 18 (15.8%) were female. The ethnic composition of this study was 47.4 % White, non-Hispanic; 42.1% Black, non-Hispanic; 7% Hispanic; and 3.5% Asian & Pacific Islander; this data is shown in Table 2. The grade level distribution was 33.3% 9th graders, 19.3% 10th graders, 33.3% 11th graders and 14% 12th graders. This data is listed in Table 3.

Table 2

*Ethnicity of Students in Research Study*

| Valid | Frequency | Percent | Valid percent | Cumulative percent |
|---|---|---|---|---|
| White, non-Hispanic | 54 | 47.4 | 47.4 | 47.4 |
| Black, non-Hispanic | 48 | 42.1 | 42.1 | 89.5 |
| Hispanic | 8 | 7.0 | 7.0 | 96.5 |
| Asian & Pacific Islander | 4 | 3.5 | 3.5 | 100.0 |
| Total | 114 | 100.0 | 100.0 | |

Table 3

*Grade Level of Students in Research Study*

| Valid | Frequency | Percent | Valid percent | Cumulative percent |
|---|---|---|---|---|
| $9^{th}$ | 38 | 33.3 | 33.3 | 33.3 |
| $10^{th}$ | 22 | 19.3 | 19.3 | 52.6 |
| $11^{th}$ | 38 | 33.3 | 33.3 | 86.0 |
| 12th | 16 | 14 | 14 | 100.0 |
| Total | 114 | 100.0 | 100.0 | |

**Instrumentation**

The TOSRA was designed to measure seven distinct science-related attitudes among secondary school students. For this quantitative study, four of the seven distinct science related attitudes were analyzed as described in chapter 2: (1) attitude of science inquiry, (2) enjoyment of science lessons, (3) leisure interest in science, and (4) career interest in science (Fraser, 1981). TOSRA items involve a response format, which requires students to express their degree of agreement with each statement on a 5-point scale consisting of the responses strongly agree (SA), agree (A), not sure (N), disagree (D), and strongly disagree (SD). Scoring involves allocating 5, 4, 3, 2, 1 for responses SA, A, N, D, SD, respectively, for items designated as positive (+) and allotting 1, 2, 3, 4, 5 for responses SA, A, N, D, SD, respectively, for items designated as negative (-), as shown in Table 4 (Fraser, 1981). The questionnaire used in this study is in Appendix A.

Table 4

*TOSRA Scale Allocation and Scoring for Each Item*

| Attitude of scientific inquiry | Enjoyment of science lessons | Leisure interest in science | Career interest in science |
|---|---|---|---|
| 1 (+) | 2 (+) | 3 (+) | 4 (-) |
| 5 (-) | 6 (-) | 7 (-) | 8(+) |
| 9 (+) | 10 (+) | 11 (+) | 12 (-) |
| 13 (-) | 14 (-) | 15 (-) | 16 (+) |
| 17 (+) | 18 (+) | 19 (+) | 20 (-) |
| 21 (-) | 22 (-) | 23 (-) | 24 (+) |
| 25 (+) | 26 (+) | 27 (+) | 28 (-) |
| 29 (-) | 30 (-) | 31 (-) | 32 (+) |
| 33 (+) | 34 (+) | 35 (+) | 36 (-) |
| 37 (-) | 38 (-) | 39 (-) | 40 (+) |

*Note.*
For positive items (+), responses SA, A, U, D, SD are scored 5, 4, 3, 2, 1, respectively. For negative items (-), responses SA, A, U, D, SD are scored 1, 2, 3, 4, 5, respectively. Omitted or invalid responses are scored 3.

The TORSA survey was measured with a 5-point Likert scale. The actual pretest and posttest scores are the sums of the items that make up the scales. Each of the pretest and posttest scales has a potential range of 10 to 50 actual summative points for the total questions students answered.

## Variables

### Independent.

A primary independent variable in this study was the grouping variable for treatment versus control group. Independent variables for subsidiary research questions specifically related to the treatment group only were grade level, gender, and ethnicity.

**Dependent.**

For the purpose of this study, pretest scores and posttest scores for the four TOSRA subscales were calculated by summing the responses of items contained in the subscale. The dependent variables in this study were the difference between the pretests and posttests of the four distinct science-related attitudes: (1) attitude of science inquiry, (2) enjoyment of science lessons, (3) leisure interest in science, and (4) career interest in science.

**Validation and Reliability of TOSRA**

According to Welch (2007), the TOSRA was designed to measure seven distinct science-related attitudes among secondary school students. TOSRA is organized into seven scales, each of which has 10 statements. The seven scales of the TOSRA are social implications of science, normality of scientists, attitude of science inquiry, adoption of scientific attitudes, enjoyment of science lessons, leisure interest in science, and career interest in science. Students are asked to indicate whether they strongly agree (SA), agree (A), are undecided or neutral (N), disagree (DA), or strongly disagree (SD) with each statement. For the purpose of the study, the researcher selected four out the seven subcategories as being the most related to the topic of the attitude and interest of the students in the NXT Robotics class. The scales selected for use in this study are attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science.

Welch (2007) conducted studies that determined that the TOSRA could be used by educators and researchers to monitor student progress towards achieving attitudinal aims. Fraser (1981) stated, “TOSRA is likely to be most useful for examining the performance of groups or classes of students” (p.1). According to Welch (2007), the TOSRA has been carefully developed and extensively field tested and has been shown to be highly reliable. The development and initial validation of the TOSRA was done in 1977, and it was revised in 1981 with students in Australia by Barry Fraser and the Australian Council for Education Research. In 1977 the instrument was validated, which involved 1,337 students in grades 7-10 from 11 different schools. Since 1977, cross-validation data has become available from new samples of secondary science classes in Australia and the United States. Welch (2007) collected cross-validation data from the administration of TOSRA in secondary science classes in the United States. Welch (2007) evaluated a study by Khalili (1984), which had a high degree of internal consistency with high school students from the United States. The internal consistency reliability (the extent to which items in a given scale measure the same attitude) was estimated for TOSRA scales using the Cronbach *a* coefficient. As shown in Table 5, the Cronbach's Alpha Reliability Coefficients from the Fraser study for inquiry of science .81, enjoyment of science lessons .91, leisure interest in science .86, and career interest in science .88; and the current study for inquiry of science .84, enjoyment of science lessons .91, leisure interest in science .85, and career interest in science .91 are acceptable.

Table 5

*Cronbach's Alpha Reliability Coefficients for the Fraser Study and the Pretest and Posttest Scales in the Current Study*

| | Current study pretest | Current study posttest | Fraser Study |
|---|---|---|---|
| Inquiry of science | .85 | .84 | .81 |
| Enjoyment of science lessons | .87 | .91 | .91 |
| Leisure interest in science | .79 | .85 | .86 |
| Career interest in science | .77 | .91 | .88 |

An advantage of conducting the TOSRA instead of other science attitude tests is that it yields a separate score for a number of different attitudinal aims as opposed to just producing one overall score.  This makes it possible to obtain a profile of attitude scores for a group of students, such as a group of students taking a specific class (treatment group) and another group that does not take that particular class (control group).

**Data Analysis**

The researcher used Statistical Package for the Social Sciences® (SPSS) software, version 17.0 for Microsoft Windows®, to enter and process data for analysis.  An analysis of covariance was conducted to determine means and standard deviations for continuous (interval/ratio) data.  This researcher was interested in whether there was a difference in terms of improvement between the pretest and posttest of the students in the treatment and control group for grade level, and treatment group for gender and ethnicity.  To answer research question one--Is there any difference in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science based on grade level and whether or not students were enrolled in the NXT Robotics elective class?—an analysis of covariance model was used to examine whether data from two groups (treatment v. control) have a common mean by grade level.  When applicable the Johnson-Neyman statistical technique was used where the test for homogeneity of slopes was tested by ANCOVA and rejected.  The Johnson-Neyman was appropriated for non-equivalent group designs.

To answer research question two--Among students in the NXT Robotics elective class (treatment group), is there a differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest based on gender?—an analysis of covariance model was used to test the null hypotheses (pretest and posttest of the treatment group) by gender.

To answer research question three--Among students in the NXT Robotics elective class (treatment group), are there differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest, based on ethnicity?—an analysis of covariance model was used to test the null hypotheses (pretest and posttest of the treatment group) by ethnicity.

**ANCOVA.**

The independent and dependent variable structures for multiple regression, factorial ANOVA and ANCOVA tests are similar. The purpose of ANCOVA is to compare two or more liner regression lines. ANCOVA is differentiated from ANOVA in that it was used because I wanted to neutralize the effect of a continuous independent variable in the study. ANCOVA was used instead of ANOVA because the independent variable of grade level, gender, and ethnicity had a strong correlation with the dependent variables of the difference between the pretests and posttest for the four distinct science related attitudes. The interpretation of ANCOVA depends on certain assumptions about the data used in the study. Analysis of covariance (ANCOVA) is used when a research study includes two measurement variables and two nominal variables. I can control for the effects of the covariate. Unlike independent variables in ANOVA, covariates do not have to be categorical, or nominal, variables. An analysis of covariance presented two applications: (1) to remove error variance in randomized experiments, and (2) equate non-equivalent groups (Ary, Jacobs, & Razavieh, 2002). Using ANCOVA, I was looking at the overall relationship between the outcome (dependent variable) and the covariate. The Johnson-Neyman statistical technique was used where the test for homogeneity of slopes was tested by an ANCOVA and rejected. The Johnson-Neyman statistical technique is appropriate when the homogeneity of slopes is rejected (Fraas & Newman, 1997). The Johnson-Neyman technique allowed the researcher to calculate the confidence bands for the regions of non-significance for scores of the pretests and posttests. According to Preacher, Curran, and Bauer (2006), the heterogeneous regression slopes required the use of the Johnson-Neyman technique to define regions of non-significance.

**Likert Scale.**

Likert scales can be used to measure ordinal- or interval-level variables. Although researchers disagree about the most appropriate level of measurement for Likert-type items (Gall, Gall, & Borg, 2010), many psychometricians would argue that Likert scales may be used as interval scales because, when well constructed, there is equal distance between each value (Jamieson, 2004; Newson, 2011; Norman, 2010). The TOSRA survey had a visual analog code with equal spacing of response levels that were clearly indicated; this makes the argument for using the data collected as interval data stronger. Interval variables have an equal distance between each value (Jamieson, 2004; Twaddle, 2010). Interval data can be used to determine differences between individuals based on some trait or characteristic, such as gender and ethnicity as used in this study (Newson, 2011; Twaddle, 2010). If a Likert scale is used as a dependent variable in an analysis, normal theory statistics are used, such as ANCOVA or regression. Likert questions or items may well be ordinal when analyzing a single question, but Likert scales consisting of sums across many items will be interval (Jamieson, 2004; Norman, 2010; Twaddle, 2010).

For this study, the researcher used the Likert scale sum of responses on several Likert items, 10 questions per attitudinal interest. When using a Likert scale such as the one in this study--strongly agree (SA), agree (A), not sure (N), disagree (D), and strongly disagree (SD)--this clearly implies the wording of response levels (SA), (A), (N), (D), or (SD). There is symmetry of response levels about a middle category. Such an item would fall between ordinal and interval level measurement; if treated as ordinal only, it would cause a loss of information (Twaddle, 2010). The Likert scale, which is one of the most common scales used in survey research, would be a practical application of the interval scale (Newson, 2010; Twaddle, 2010). Likert scales may be subject to distortion because students may think they need to answer a question a certain way to portray a favorable response from the teacher.

The researcher stressed to the study participants that the TOSRA survey was anonymous and confidential, with no grades being assigned for the responses. Responses to several Likert questions may be summed, provided that all questions use the same Likert scale and that the scale is a defendable approximation to an interval scale; if the summed responses fulfill these assumptions, parametric statistical tests such as the analysis of variance can be applied (Jamieson, 2004; Newson, 2011; Norman, 2010). The survey categories, attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science, had to be analyzed separately, and the item responses would be summed to create a score for a group of items.

The following research questions guided this study.

*Research Question 1.* Are there differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science based on grade level and whether or not students were enrolled in the NXT Robotics elective class? To answer this research question, an analysis of covariance model was used to evaluate the following null hypotheses:

(Attitude of Science Inquiry)

$Ho1_1$: There is no difference in the attitude of science inquiry means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_2$: There are no differences in the attitude of science inquiry means among students in different grade levels.

(Enjoyment of Science Lessons)

$Ho1_4$: There is no difference in the enjoyment of science lessons means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_5$: There are no differences in the enjoyment of science lessons means among students in different grade levels.

(Leisure Interest in Science)

$Ho1_7$: There is no difference in the leisure interest in science means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_8$: There are no differences in the leisure interest in science means among students in different grade levels.

(Career Interest in Science)

$Ho1_{10}$: There is no difference in the career interest in science means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_{11}$: There are no differences in the career interest in science means among students in different grade levels.

*Research Question 2.* Among students in the NXT Robotics elective class (treatment group), are there differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest based on gender? To answer this research question, an analysis of covariance model was used to evaluate the following null hypotheses:

$Ho2_1$: Among students in the treatment group, there is no difference in the attitude of science inquiry means between male and female students.

$Ho2_2$: Among students in the treatment group, there is no difference in the enjoyment of science lessons means between male and female students.

$Ho2_3$: Among students in the treatment group, there is no difference in the leisure interest in science means between male and female students.

$Ho2_4$: Among students in the treatment group, there is no difference in the career interest in science means between male and female students.

*Research Question 3.* Among students in the NXT Robotics elective class (treatment group), are there differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest based on ethnicity? To answer this research question, an analysis of covariance model was used to evaluate the following null hypotheses:

$Ho3_1$: Among students in the treatment group, there are no differences in the attitude of science inquiry means among ethnic groups.

$Ho3_2$: Among students in the treatment group, there are no differences in the enjoyment of science lessons means among ethnic groups.

$Ho3_3$: Among students in the treatment group, there are no differences in the leisure interest in science means among ethnic groups.

$Ho3_4$: Among students in the treatment group, there are no differences in the career interest in science gain score means among ethnic groups.

**Procedure**

For the purpose of this study, the researcher first obtained written permission from the superintendent of the school division to survey the NXT Robotics and science classes. The 114 students selected for the study included 57 from the treatment group and 57 from the control group. Students completed the pretest survey on April 2, 2010, and the posttest survey on June 2, 2010. The surveys completed by the treatment group were proctored by the NXT Robotics teachers, and the surveys completed by the control group were proctored by the researcher. All students who participated in the study were required to have a parental consent form signed and returned to the researcher (Appendix B). The respective proctors read the student informed consent form before the students started the survey (Appendix C). The students were allocated a 40-minute time frame to complete the 40-question TOSRA. The same procedure was followed for the pretest and posttest survey. The limitation of the treatment group is that they were not selected randomly; current students in the NXT Robotics class participated in the study. The TOSRA is an attitude survey that is taken confidentially and anonymously. It is not used to grade the students, so it is assumed that the students provided accurate information on the survey.

**Summary**

The study examined the attitudes and interests of two groups of students in a rural school division. Students in the treatment group were enrolled in an 18-week NXT Robotics class that incorporated STEM activities into the curriculum but not core science classes. Students in the control group were enrolled in core science classes but not the NXT Robotics class. The researcher used analysis of covariance to determine if there was a significant difference between the means of the treatment and control groups. Using ANCOVA to analyze the mean difference in posttest scores adjusted for the pretest scores, to evaluate the treatment and control groups in the areas of attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science by grade, gender, and ethnicity. When applicable the Johnson-Neyman statistical technique was used where the test for homogeneity of slopes was tested by ANCOVA and rejected. The Johnson-Neyman was appropriated for non-equivalent group designs.

# Chapter Four: Results

## Introduction

The purpose of this study was to find out if students who were exposed to the NXT Robotics curriculum had a change in attitude and interest in science. The research questions were analyzed, along with their null hypotheses. Specifically, the study investigated whether there were significant differences in pretest and posttest scores in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science between students enrolled in the NXT Robotics class but not the science class (treatment group), and students enrolled in a regular science class but not the NXT Robotics class (control group), based on grade level. In addition, the study investigated whether there were differences in the students (treatment group) enrolled in the NXT Robotics class based on gender and ethnicity.

## Hypotheses Testing

*Research Question 1.* Are there differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science based on grade level and whether or not students were enrolled in the NXT Robotics elective class. To answer this research question, an analysis of covariance model was used to evaluate the following null hypotheses:

(Attitude of Science Inquiry)

$Ho1_1$: There is no difference in the attitude of science inquiry means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_2$: There are no differences in the attitude of science inquiry means among students in different grade levels.

A two-way analysis of covariance was used to evaluate the mean differences in posttest inquiry of science scores adjusted for the pretest inquiry of science scores. The dependent variable was posttest inquiry of science scores while the covariate was the pretest inquiry of science scores. The two factors were the grouping variable (treatment versus control group) and grade level with four levels ($9^{th}$, $10^{th}$, $11^{th}$ and $12^{th}$ grades).

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using two interaction terms: group by pretest and grade level by pretest. The null hypothesis for the homogeneity of slopes for the grouping variable was not significant, $F$ (1, 104) = .086, $p$ = .770. Likewise, the null hypothesis for the homogeneity of slopes for grade levels was not significant, $F$ (3, 104) = 1.182, $p$ = .320. Because the assumption of homogeneity of slopes for each factor was met, an ANCOVA was conducted.

After adjustment for the pretest, there was no significant difference between the treatment and control groups' adjusted posttest inquiry of science means, $F$ (1, 108) = .928, $p$ = .337. Therefore, the null hypothesis was retained. The effect size as measured by $\eta^2$ was small (.01). That is, only 1% of the variance in posttest inquiry of science scores was accounted for by the grouping variable. There was very little difference between adjusted posttest inquiry of science mean for the treatment group ($M_{adj}$ = 41.712, $SE$ = .909) and the control group ($M_{adj}$ = 42.926, $SE$ = .911).

There was no difference among the adjusted posttest inquiry of science means among the grade levels, $F$ (3, 108) = 1.451, $p$ = .232. Therefore, the null hypothesis was retained. The effect size was small (.04) indicating that 4% of the variance in posttest inquiry of science scores was accounted for by grade level. Table 6 shows the adjusted posttest inquiry of science means by grade level.

Table 6

*Adjusted Posttest Inquiry of Science Means and Standard Errors by Grade Levels*

| Grade level | *N* | Adjusted *M* | *SE* |
|---|---|---|---|
| 9 | 38 | 41.187 | 1.068 |
| 10 | 22 | 41.384 | 1.399 |
| 11 | 38 | 41.644 | 1.066 |
| 12 | 16 | 45.060 | 1.640 |

(Enjoyment of Science Lessons)

$Ho1_4$: There is no difference in the enjoyment of science lessons means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

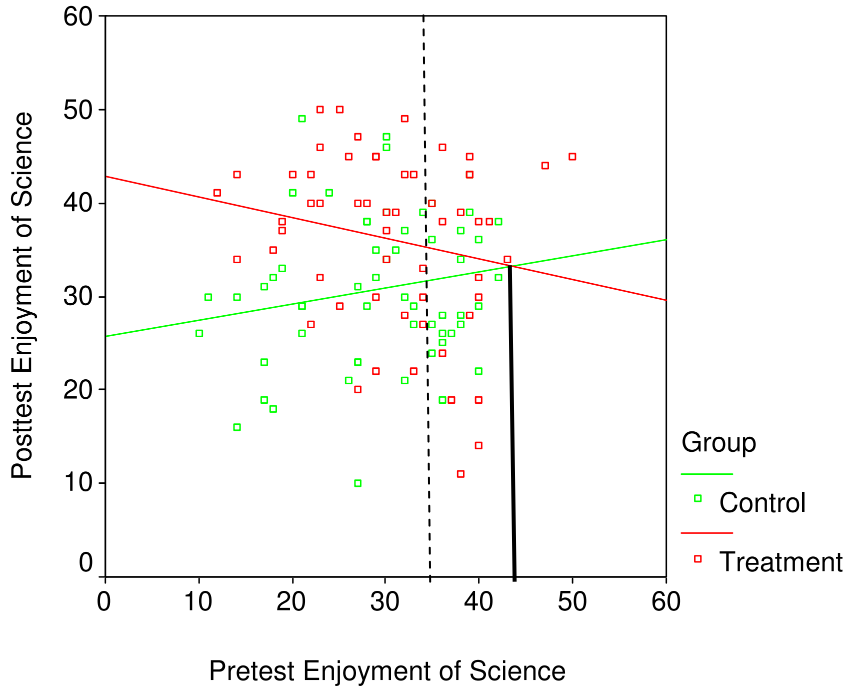
$Ho1_5$: There are no differences in the enjoyment of science lessons means among students in different grade levels.

Prior to conducting the analysis of covariance model to evaluate the differences in the adjusted enjoyment of science means for the grouping variable and grade levels, tests for the homogeneity of slopes were performed using two interaction terms: group by enjoyment of science pretest scores and grade level by enjoyment of science pretest scores. The interaction term for group by pretest was significant, $F$ (1, 104) = 5.159, $p$ = .025. Because the assumption of homogeneity of slopes was not met for the grouping variable, ANCOVA was not used to evaluate adjusted enjoyment of science means for the grouping variable. Instead, the nature of the group by pretest interaction was explored.

As shown in Figure 1 there was a weak negative relationship between the pretest and posttest enjoyment of science scores for the treatment group ($r$ = -.223), while the relationship between the pretest and posttest for the control group was positive, but weak ($r$ = .172). The point of intersection (denoted by the solid vertical line) where the two regression lines intersect was 43.5. The Johnson-Neyman Region of Nonsignificance was calculated to determine where the treatment and control groups differed. The region of nonsignificance was 34.33 to 433.22. Because the upper bound far exceeded the range of interest, only the lower bound (denoted by the dashed vertical line) was included in the figure. Regarding the lower bound of the Johnson-Neyman Region of Nonsignificance, there was a significant difference between the control and treatment groups for students who scored less than 34.33 on the enjoyment of science pretest. Specifically, students in the treatment group had higher posttest enjoyment of science scores than students in the control group. Because the upper bound of the region of nonsignificance was well beyond scores of interest (and were not possible given the instrument used to measure the variable), it can be concluded that for students who scored higher than 34.33 on the pretest, there was no difference between the treatment and control groups' posttest enjoyment of science scores.

Figure 1

*Scatterplot of Pretest and Posttest Enjoyment of Science by Group*




$\hat{y}_{\text{Control}} = 25.752 + .172x$

$\hat{y}_{\text{Treatment}} = 42.933 - .223x$

Note: The point of intersection is 43.5; the lower bound of the region of nonsignificance was 34.33.

The grade by enjoyment of science pretest interaction term was not significant, *F* (3, 104) = .641, *p* = .590. Therefore, the assumption of homogeneity of slopes for grade levels was met and ANCOVA was used to evaluate the adjusted enjoyment of science means for grade levels. The ANCOVA for grade level was significant, *F* 3, 108) = 4.394, *p* = .006. The effect size as measured by $\eta^2$ was medium (.11). Because the *F* test for grade level was significant, the Tukey post hoc test was used to determine which pair of means was significantly different.

The Tukey test showed there was a significant difference between the adjusted means for 12th grade students and 9th grade students ($p$ = .012). There was also a significant difference between 12th grade students and 10th grade students ($p$ = .014). The adjusted mean for 12th graders was almost 8 points higher than the mean for 9th graders and 8.5 points higher than the mean for 10th graders. Table 7 shows the adjusted enjoyment of science means and standard errors by grade levels.

Table 7

*Adjusted Posttest Enjoyment of Science Means and Standard Errors by Grade Levels*

| Grade level | *N* | Adjusted *M* | *SE* |
|---|---|---|---|
| 9 | 38 | 31.285 | 1.354 |
| 10 | 22 | 30.645 | 1.780 |
| 11 | 38 | 34.768 | 1.354 |
| 12 | 16 | 39.049 | 2.088 |

(Leisure Interest in Science)

$Ho1_7$: There is no difference in the leisure interest in science means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_8$: There are no differences in the leisure interest in science means among students in different grade levels.

A two-way analysis of covariance was used to evaluate the mean differences in posttest leisure interest in science scores adjusted for the pretest leisure interest in science scores. The dependent variable was posttest leisure interest in science scores while the covariate was the pretest leisure interest in science scores. The two factors were the grouping variable (treatment versus control group) and grade level with four levels ($9^{th}$, $10^{th}$, $11^{th}$ and $12^{th}$ grades).

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using two interaction terms: group by pretest and grade level by pretest. The null hypothesis for the homogeneity of slopes for the grouping variable was not significant, $F$ (1, 104) = .015, $p$ = .902. Likewise, the null hypothesis for the homogeneity of slopes for grade levels was not significant, $F$ (3, 104) = .826, $p$ = .483. Because the assumption of homogeneity of slopes for each factor was met, an ANCOVA was conducted.

After adjustment for the pretest, there was no significant difference between the treatment and control groups' adjusted posttest leisure interest in science means, $F$ (1, 108) = 14.485, $p$ = .000. Therefore, the null hypothesis was retained. The effect size as measured by $\eta^2$ was medium (.12). That is, only 12% of the variance in posttest leisure interest in science scores was accounted for by the grouping variable. There was very little difference between adjusted posttest leisure interest in science mean for the treatment group ($M_{adj}$ = 30.842, $SE$ = 1.067) and the control group ($M_{adj}$ = 25.267, $SE$ = 1.064).

There was no difference among the adjusted posttest leisure interest in science means among the grade levels, $F$ (3, 108) = 2.474, $p$ = .065. Therefore, the null hypothesis was retained. The effect size was small (.06) indicating that 6% of the variance in posttest leisure interest in science scores was accounted for by grade level. Table 8 shows the adjusted posttest leisure interest in science means by grade level.

Table 8

*Adjusted Posttest Leisure Interest in Science Means and Standard Errors by Grade Levels*

| Grade level | *N* | Adjusted *M* | *SE* |
|---|---|---|---|
| 9 | 38 | 26.445 | 1.257 |
| 10 | 22 | 25.500 | 1.647 |
| 11 | 38 | 29.713 | 1.262 |
| 12 | 16 | 30.561 | 1.934 |

(Career Interest in Science)

$Ho1_{10}$: There is no difference in the career interest in science means between students in the NXT Robotics elective class (treatment group) and students who do not participate in the class (control group).

$Ho1_{11}$: There are no differences in the career interest in science means among students in different grade levels.

A two-way analysis of covariance was used to evaluate the mean differences in posttest career interest in science scores adjusted for the pretest career interest in science scores. The dependent variable was posttest career interest in science scores while the covariate was the pretest career interest in science scores. The two factors were the grouping variable (treatment versus control group) and grade level with four levels ($9^{th}$, $10^{th}$, $11^{th}$ and $12^{th}$ grades).

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using two interaction terms: group by pretest and grade level by pretest. The null hypothesis for the homogeneity of slopes for the grouping variable was not significant, $F$ (1, 104) = 1.447, $p$ = .232. Likewise, the null hypothesis for the homogeneity of slopes for grade levels was not significant, $F$ (3, 104) = .122, $p$ = .947. Because the assumption of homogeneity of slopes for each factor was met, an ANCOVA was conducted.

After adjustment for the pretest, there was a significant difference between the treatment and control groups' adjusted posttest career interest in science means, $F$ (1, 108) = 8.934, $p$ = .003. Therefore, the null hypothesis was rejected. The effect size as measured by $\eta^2$ was medium (.08). That is, 8% of the variance in posttest career interest in science scores was accounted for by the grouping variable. The adjusted career interest in science mean for the treatment group ($M_{adj}$ = 34.616, $SE$ = 1.146) was over 4.5 points higher than the mean for the control group ($M_{adj}$ = 29.935, $SE$ = 1.145).

There was a difference among the adjusted posttest career interest in science means among the grade levels, $F$ (3, 108) = 7.512, $p < .001$. Therefore, the null hypothesis was rejected. The effect size was large (.17) indicating that 17% of the variance in posttest career interest in science scores was accounted for by grade level. Follow up analysis for grade level using the Tukey post hoc pairwise comparisons test showed there was a significant difference in the adjusted career interest in science means between $9^{th}$ and $11^{th}$ grade students ($p$ = .011) and between $9^{th}$ and $12^{th}$ grade students ($p$ =.001). The mean for $9^{th}$ graders was lower than the mean for both $11^{th}$ graders and $12^{th}$ graders. The adjusted career interest in science mean for $10^{th}$ grade students was different from the mean for $12^{th}$ graders ($p$ = .007). No other pairing was significant. Table 9 shows the adjusted posttest career interest in science means by grade level.

Table 9

*Adjusted Posttest Career Interest in Science Means and Standard Errors by Grade Levels*

| Grade level | *N* | Adjusted *M* | *SE* |
|---|---|---|---|
| 9 | 38 | 27.793 | 1.354 |
| 10 | 22 | 29.226 | 1.780 |
| 11 | 38 | 33.844 | 1.356 |
| 12 | 16 | 38.238 | 2.092 |

*Research Question 2.* Among students in the NXT Robotics elective class (treatment group), are there differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science based on gender? To answer this research question, an analysis of covariance model was used to evaluate the following null hypotheses:

$Ho2_1$: Among students in the treatment group, there is no difference in the attitude of science inquiry means between male and female students.

A one-way analysis of covariance was used to evaluate the mean differences in posttest inquiry of science scores adjusted for the pretest inquiry of science scores. The dependent variable was posttest inquiry of science scores while the covariate was the pretest inquiry of science scores. The grouping variable was the gender of the students in the treatment group.

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using the gender by pretest interaction term. The gender by pretest inquiry interaction was not significant, $F\ (1, 53) = 1.048$, $p = .331$. Therefore, the assumption of homogeneity of slopes was met and ANCOVA was used.

After adjustment for the pretest, there was no significant difference in the adjusted inquiry of science means between male and female students, $F$ (1, 54) = .320, $p$ = .574. Therefore, the null hypothesis was retained. The effect size as measured by $\eta^2$ was small (.01). That is, only 1% of the variance in adjusted inquiry of science scores was accounted for by gender. There was very little difference between adjusted posttest inquiry of science mean for males ($M_{adj}$ = 41.468, $SE$ = 1.065) and females ($M_{adj}$ = 39.950, $SE$ = 2.462).

$Ho2_2$: Among students in the treatment group, there is no difference in the enjoyment of science lessons means between male and female students.

A one-way analysis of covariance was used to evaluate the mean differences in posttest enjoyment of science lessons scores adjusted for the pretest enjoyment of science lessons scores. The dependent variable was posttest enjoyment of science lessons scores while the covariate was the pretest enjoyment of science lessons scores. The grouping variable was the gender of the students in the treatment group.

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using the gender by pretest interaction term. The gender by pretest enjoyment of science lessons interaction was not significant, $F$ (1, 53) = 1.444, $p$ = .245. Therefore, the assumption of homogeneity of slopes was met and ANCOVA could be used.

After adjustment for the pretest, there was no significant difference in the adjusted enjoyment of science lessons means between male and female students, $F$ (1, 54) = .154, $p$ = .696. Therefore, the null hypothesis was retained. The effect size as measured by $\eta^2$ was small (< .01). That is, 1% of the variance in adjusted posttest enjoyment of science lessons scores was accounted for by gender. There was very little difference between adjusted posttest enjoyment of science lessons mean for males ($M_{adj}$ = 35.862, $SE$ = 1.334) and females ($M_{adj}$ = 37.181, $SE$ = 3.086).

Ho2$_3$: Among students in the treatment group, there is no difference in the leisure interest in science means between male and female students.

A one-way analysis of covariance was used to evaluate the mean differences in posttest leisure interest in science scores adjusted for the pretest leisure interest in science scores. The dependent variable was posttest leisure interest in science scores while the covariate was the pretest leisure interest in science scores. The grouping variable was the gender of the students in the treatment group.

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using the gender by pretest interaction term. The gender by pretest leisure interest in science interaction was not significant, $F$ (1, 53) = .070, $p$ = .792. Therefore, the assumption of homogeneity of slopes was met and ANCOVA could be used.

After adjustment for the pretest, there was no significant difference in the adjusted leisure interest in science means between male and female students, $F$ (1, 54) = .588, $p$ = .447. Therefore, the null hypothesis was retained. The effect size as measured by $\eta^2$ was small (.01). That is, 1% of the variance in adjusted posttest leisure interest in science scores was accounted for by gender. There was very little difference between adjusted posttest leisure interest in science mean for males ($M_{adj}$ = 30.358, $SE$ = 1.179) and females ($M_{adj}$ = 32.647, $SE$ = 2.736).

Ho2$_4$: Among students in the treatment group, there is no difference in the career interest in science means between male and female students.

A one-way analysis of covariance was used to evaluate the mean differences in posttest career interest in science scores adjusted for the pretest career interest in science scores. The dependent variable was posttest career interest in science scores while the covariate was the pretest career interest in science scores. The grouping variable was the gender of the students in the treatment group.

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using the gender by pretest interaction term. The gender by pretest career interest in science interaction was not significant, $F\ (1, 53) = 1.331$, $p = .254$. Therefore, the assumption of homogeneity of slopes was met and ANCOVA could be used.

After adjustment for the pretest, there was no significant difference in the adjusted career interest in science means between male and female students, $F\ (1, 54) = .024$, $p = .877$. Therefore, the null hypothesis was retained. The effect size as measured by $\eta^2$ was small (< .01). That is, 1% of the variance in adjusted posttest career interest in science scores was accounted for by gender. There was very little difference between adjusted posttest career interest in science mean for males ($M_{adj} = 33.793$, $SE = 1.353$) and females ($M_{adj} = 34.327$, $SE = 3.144$).

*Research Question 3.* Among students in the NXT Robotics elective class (treatment group), are there differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science based on ethnicity? To answer this research question, an analysis of covariance model was used to evaluate the following null hypotheses:

$Ho3_1$: Among students in the treatment group, there are no differences in the attitude of science inquiry means among ethnic groups.

A one-way analysis of covariance was used to evaluate the mean differences in posttest inquiry of science scores adjusted for the pretest inquiry of science scores. The dependent variable was posttest inquiry of science scores while the covariate was the pretest inquiry of science scores. The grouping variable was the ethnicity: (1) White, non-Hispanic; (2) Black, non-Hispanic; (3) Hispanic; and (4) Asian or Pacific Islander; of the students in the treatment group.

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using the ethnicity by pretest interaction term. The ethnicity by pretest inquiry of science interaction was not significant, $F$ (3, 49) = 2.206, $p$ = .099. Therefore, the assumption of homogeneity of slopes was met and ANCOVA was used.

After adjustment for the pretest, there was no significant difference in the adjusted inquiry of science means among the ethnic groups, $F$ (3, 52) = 1.670, $p$ = .185. Therefore, the null hypothesis was retained. The effect size as measured by $\eta^2$ was medium (.09). That is, 9% of the variance in adjusted inquiry of science scores was accounted for by ethnic group. Because there was no significant difference among the ethnic groups, pairwise comparisons were not conducted. Table 10 shows the adjusted posttest inquiry of science means by ethnicity.

Table 10

*Adjusted Posttest Inquiry of Science Means and Standard Errors by Ethnicity*

| Ethnicity | *N* | Adjusted *M* | *SE* |
|---|---|---|---|
| White, non-Hispanic | 27 | 43.088 | 1.395 |
| Black, non-Hispanic | 24 | 38.815 | 1.479 |
| Hispanic | 4 | 43.799 | 3.616 |
| Asian or Pacific Islander | 2 | 39.944 | 5.107 |

$Ho3_2$: Among students in the treatment group, there are no differences in the enjoyment of science lessons means among ethnic groups.

A one-way analysis of covariance was used to evaluate the mean differences in posttest enjoyment of science lessons scores adjusted for the pretest enjoyment of science lessons scores. The dependent variable was posttest enjoyment of science lessons scores while the covariate was the pretest enjoyment of science lessons scores. The grouping variable was the ethnicity: (1) White, non-Hispanic; (2) Black, non-Hispanic; (3) Hispanic; and (4) Asian or Pacific Islander; of the students in the treatment group.

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using the ethnicity by pretest interaction term. The ethnicity by pretest enjoyment of science lessons interaction term was not significant, $F$ (3, 49) = 1.191, $p$ = .323. Therefore, the assumption of homogeneity of slopes (parallel slopes) was not violated and ANCOVA could be used.

After adjustment for the pretest, there was a significant difference in the adjusted enjoyment of science lessons means among the ethnic groups, $F$ (3, 52) = 5.827, $p$ = .002. Therefore, the null hypothesis was rejected. The effect size as measured by $\eta^2$ was large (.25). That is, 25% of the variance in adjusted enjoyment of science lessons scores was accounted for by ethnic group. Because the $F$ test was significant, the Tukey post hoc test was used to determine which pair of means was different. There was a significant difference between White, non-Hispanic students and Black, non-Hispanic students ($p$ = .001). The adjusted enjoyment of science lessons mean for White, non-Hispanic students was over 9 points higher than the mean for Black, non-Hispanic students. No other pairs of adjusted means were significantly different. Table 11 shows the adjusted posttest enjoyment of science lessons means by ethnicity.

Table 11

*Adjusted Posttest Enjoyment of Science Means and Standard Errors by Ethnicity*

| Ethnicity | *N* | Adjusted *M* | *SE* |
|---|---|---|---|
| White, non-Hispanic | 27 | 40.147 | 1.571 |
| Black, non-Hispanic | 24 | 31.037 | 1.668 |
| Hispanic | 4 | 40.627 | 4.080 |
| Asian or Pacific Islander | 2 | 32.318 | 5.772 |

$Ho3_3$: Among students in the treatment group, there are no differences in the leisure interest in science means among ethnic groups.

A one-way analysis of covariance was used to evaluate the mean differences in posttest leisure interest in science scores adjusted for the pretest leisure interest in science scores. The dependent variable was posttest leisure interest in science scores while the covariate was the pretest leisure interest in science scores. The grouping variable was the ethnicity: (1) White, non-Hispanic; (2) Black, non-Hispanic; (3) Hispanic; and (4) Asian or Pacific Islander; of the students in the treatment group.

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using the ethnicity by pretest interaction term. The ethnicity by pretest leisure interest in science interaction term was not significant, $F$ (3, 49) = .423, $p$ = .738. Therefore, the assumption of homogeneity of slopes was met and ANCOVA could be used.

After adjustment for the pretest, there was a significant difference in the adjusted leisure interest in science means among the ethnic groups, $F$ (3, 52) = 3.197, $p$ = .031. Therefore, the null hypothesis was rejected. The effect size as measured by $\eta^2$ was large (.16). That is, 16% of the variance in adjusted leisure interest in science scores was accounted for by ethnic group.

Because the *F* test was significant, the Tukey post hoc test was used to determine which pair of means was different. There was a significant difference between White, non-Hispanic students and Black, non-Hispanic students ($p$ = .048). The adjusted leisure interest in science mean for White, non-Hispanic students was over 6 points higher than the mean for Black, non-Hispanic students. No other pairs of adjusted means were significant. Table 12 shows the adjusted posttest leisure interest in science means by ethnicity.

Table 12

*Adjusted Posttest Leisure Interest in Science Means and Standard Errors by Ethnicity*

| Ethnicity | *N* | Adjusted *M* | *SE* |
|---|---|---|---|
| White, non-Hispanic | 27 | 33.197 | 1.478 |
| Black, non-Hispanic | 24 | 27.089 | 1.570 |
| Hispanic | 4 | 35.336 | 3.845 |
| Asian or Pacific Islander | 2 | 31.599 | 5.435 |

$Ho3_4$: Among students in the treatment group, there are no differences in the career interest in science means among ethnic groups.

A one-way analysis of covariance was used to evaluate the mean differences in posttest career interest in science scores adjusted for the pretest career interest in science scores. The dependent variable was posttest career interest in science scores while the covariate was the pretest career interest in science scores. The grouping variable was the ethnicity: (1) White, non-Hispanic; (2) Black, non-Hispanic; (3) Hispanic; and (4) Asian or Pacific Islander; of the students in the treatment group.

Prior to conducting the analysis of covariance, the assumption of the homogeneity of slopes was tested using the ethnicity by pretest interaction term. The ethnicity by pretest career interest in science interaction term was not significant, $F$ (3, 49) = 1.984, $p$ = .129. Therefore, the assumption of homogeneity of slopes was met and ANCOVA was used.

There was a significant difference in the adjusted career interest in science means among the ethnic groups, $F$ (3, 52) = 6.183, $p$ = .001. Therefore, the null hypothesis was rejected. The effect size as measured by $\eta^2$ was large (.26). That is, 26% of the variance in adjusted career interest in science scores was accounted for by ethnic group. Because the overall $F$ test was significant, the Tukey post hoc test was used to determine which pair(s) of means was different. The Tukey procedure showed there was a significant difference in the adjusted career interest in science between Black, non-Hispanic and White, Non-Hispanic students ($p$ = .001). Likewise, the mean for Black, non-Hispanic students was significantly different from the mean for Hispanic students ($p$ = .036). The mean for Black, non-Hispanic students was over 9 points lower than the mean for White, non-Hispanics and over 12 points lower than the mean for Hispanic students. No other pairs of adjusted means were significantly different. Table 13 shows the adjusted posttest career interest in science means by ethnicity.

Table 13

*Adjusted Posttest Career Interest in Science Means and Standard Errors by Ethnicity*

| Ethnicity | *N* | Adjusted *M* | *SE* |
|---|---|---|---|
| White, non-Hispanic | 27 | 37.604 | 1.578 |
| Black, non-Hispanic | 24 | 28.595 | 1.673 |
| Hispanic | 4 | 40.932 | 4.099 |
| Asian or Pacific Islander | 2 | 32.844 | 5.800 |

## Summary

The purpose of this study was to evaluate the impact of the NXT Robotics class on students' attitudes and interest in science. Students' attitudes and interest in science were measured by four sub-scales of the TORSA questionnaire. Data were collected through pretest and posttests in four areas: (1) attitude of science inquiry; (2) enjoyment of science lessons; (3) leisure interest in science; and (4) career interest in science. Using ANCOVA the researcher was looking at the overall relationship between the outcome (dependent variable) and the covariate.

For research question one a two-way analysis of covariance was used to evaluate the mean difference in posttest scores adjusted for the pretest scores. The dependent variable was the posttest scores while the covariate was the pretest scores. The two factors were the grouping variable in the treatment and control groups and the grade level of the students. The ANCOVA models were not significant and the null hypotheses were retained for the group by grade level interaction in attitude of science inquiry and leisure interest in science. However, career interest in science there was a significant difference and the null hypothesis was rejected. The enjoyment of science lessons the interaction term for group by pretest was significant and the assumption of homogeneity of slopes was not met for the grouping variable. ANCOVA was not used to evaluate adjusted means for the grouping variable. Therefore, the nature of the group by pretest interaction was explored. The Johnson-Neyman Region of Nonsignificance was used to determine where the treatment and control groups differed.

For research question two, a one-way analysis of covariance was used to evaluate the mean difference in the posttest scores adjusted for the pretest scores. The dependent variable was posttest scores while the covariate was the pretest scores. The grouping variable was the gender of the students in the treatment group. For students in the treatment group the ANCOVA models were not significant, and the null hypotheses were retained for the group by gender interaction in attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science.

Research question three a one-way analysis of covariance was used to evaluate the mean difference in the posttest scores adjusted for the pretest scores. The dependent variable was posttest scores while the covariate was the pretest scores. The grouping variable was the ethnicity: (1) White, non-Hispanic; (2) Black, non-Hispanic; (3) Hispanic; and (4) Asian or Pacific Islander; of the students in the treatment group. For students in the treatment group the ANCOVA model were not significant, and the null hypothesis was retained for the group by ethnicity interaction for attitude of science inquiry. However, the enjoyment of science lessons, leisure interest in science, and career interest in science the ANCOVA model was significant and the null hypotheses were rejected.

## Chapter Five: Summary Discussion

The final chapter of this study consists of a restatement of the problem and the purpose of the study, a review of the methodology, a summary of the findings, the implications of the study in relationship to the literature, limitations and recommendations for future studies, and the conclusion.

### Restatement of the Problem

With the passing of NCLB requirements, school divisions have been focused on high-stakes testing in the core subjects. Many students are graduating from high school without the knowledge necessary to make an informed decision about postsecondary educational interests and careers in the sciences (Genalo, 2004; Losen & Wald, 2005). In order for the U.S. to be globally competitive, postsecondary schools need to produce more scientists and engineers (Bottoms & Anthony, 2005; Daniel, 2006).

### Review of the Methodology

The purpose of this study was to evaluate the NXT Robotics program to analyze how it affected high school students' attitudes and interests towards science. The NXT Robotics program was used to connect the educational disciplines of science, mathematics, engineering, and technology. Research subjects were evaluated in four areas: attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science. This researcher was interested in whether there was a difference in terms of improvement between the pretest and posttest of the students in the treatment vs. control group based on grade level.

The researcher analyzed the treatment group scores to find out if there was a difference in terms of improvement between the pretest and posttest based of gender and ethnicity. The ANCOVA model was used to evaluate the mean differences in the posttest scores adjusted for the pretest scores. The Johnson-Neyman statistical technique was used where the test for homogeneity of slopes was tested by an analysis of covariance was rejected (Frass & Newman, 1997).

**Summary of the Findings**

This study was conducted to determine if the NXT Robotics curriculum had an effect on students' attitude and interest in science. Research question one was developed to determine if there were differences in the attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science, based on grade level and whether or not students were enrolled in the NXT Robotics elective class. Evaluation between students in the treatment group and the control group was statistically analyzed using a two-way analysis of covariance. ANCOVA was used to evaluate the mean difference on posttest scores adjusted for the pretest score serving as the covariate. The two factors were the grouping variable (treatment versus control group) and grade level with four levels ($9^{th}$, $10^{th}$, $11^{th}$, and $12^{th}$ graders). The attitude of science inquiry determined students' acceptance of science inquiry as a way of thought in their classes. The assumption of homogeneity of slopes was met for each factor (group and grade level); consequently an ANCOVA was conducted. There was no significant difference between the treatment and control group; therefore, the null hypothesis was retained. There was very little difference between adjusted posttest mean for the treatment group ($M_{adj}$ = 41.712, $SE$ = .909) and the control group ($M_{adj}$ = 42.926, $SE$ = .911). The enjoyment of science lessons determined the students' enjoyment of science learning experiences. The assumption of homogeneity of slopes was not met for the grouping variable; ANCOVA was not used to evaluate adjusted means. The nature of the group by pretest interaction was explored. The Johnson-Neymam Region of Nonsignificance was used to determine where the treatment and control group differed. It was concluded that there was no difference between the treatment and control groups' posttest scores. The ANCOVA for grade level was significant, because the *F* test was significant so the Tukey post hoc test was used to determine which pair of means was significantly different. There was a significant difference between the adjusted means for 12$^{th}$ grade and 9$^{th}$ grade students ($p$ = .012). There was also a significant difference between 12$^{th}$ grade and 10$^{th}$ grade students ($p$ = .014). The adjusted mean for 12$^{th}$ grade students was 8 points higher than the mean for 9$^{th}$ grade and 8.5 points higher than the mean for 10$^{th}$ grade students. The leisure interest in science determined the students' development of interest in science and science-related activities. The assumption of homogeneity of slopes was met for each factor (group and grade level); consequently an ANCOVA was conducted. There was no significant difference between the treatment and control group; therefore, the null hypothesis was retained. There was very little difference between adjusted posttest mean for the treatment group ($M_{adj}$ = 30.842, *SE* = 1.067) and the control group ($M_{adj}$ = 25.267, *SE* = 1.064). The career interest in science determined the students' development of interest in pursuing a career in science. The assumption of homogeneity of slopes was met for each factor group and grade level so an ANCOVA was conducted. By grouping variable there was a significant difference between the treatment and control group; therefore, the null hypothesis was rejected. The adjusted mean for the treatment group ($M_{adj}$ = 34.616, *SE* = 1.146) was more than 4.5 points higher than the mean for the control group ($M_{adj}$ = 29.935, *SE* = 1.145). There was a difference among the adjusted means among grade level; therefore, the null hypothesis was rejected. The follow up analysis for grade level using Tukey post hoc pairwise comparisons tests did show a significant difference in the adjusted means between 9th and 11th grade ($p$ = .011) and between 9th and 12th grade ($p$ = .001). The mean for 9th grade was lower than the mean for both 11th and 12th grade. The mean for 10th grade was different from the mean for 12th grade ($p$ = .007). No other paring was significant.

Research question two was developed to determine if there were differences in the students in the NXT Robotics elective class (treatment group) for attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science based on gender. A one-way analysis of covariance was used to evaluate the mean difference in posttest scores adjusted for the pretest scores. The dependent variable was posttest scores while the covariate was the pretest scores and the grouping variable was the gender. There were 57 students in the treatment group; out of the 57 students, there were 48 males and 9 females. The attitude of science inquiry determined students' acceptance of science inquiry as a way of thought in their classes. The assumption of the homogeneity of slopes was met and ANCOVA was used. There was no significant difference in the adjusted means between the male and female students; therefore, the null hypothesis was retained. There was very little difference between the adjusted posttest mean for males ($M_{adj}$ = 41.468, $SE$ = 1.065) and females ($M_{adj}$ = 39.950, $SE$ = 2.462). The enjoyment of science lessons determined the students' enjoyment of science learning experiences. The assumption of homogeneity of slopes was met and ANCOVA could be used. There was no significant difference in the adjusted means between the male and female students; therefore the null hypothesis was retained. There was very little difference between the adjusted posttest mean for males ($M_{adj}$ = 35.862, $SE$ = 1.334) and females ($M_{adj}$ = 37.181, $SE$ = 3.086).

The leisure interest in science determined the students' development of interest in science and science-related activities. The assumption of homogeneity of slopes was met and ANCOVA could be used. There was no significant difference in the adjusted means between the male and female students; therefore, the null hypothesis was retained. There was very little difference between the adjusted posttest mean for males ($M_{adj}$ = 30.358, *SE* = 1.179) and females ($M_{adj}$ = 32.647, *SE* = 2.736). The career interest in science determined the students' development of interest in pursuing a career in science. The assumption of homogeneity of slopes was met and ANCOVA could be used. There was no significant difference in the adjusted means between the male and female students; therefore, the null hypothesis was retained. There was very little difference between the adjusted posttest mean for males ($M_{adj}$ = 33.793, *SE* = 1.353) and females ($M_{adj}$ = 34.327, *SE* = 3.144). Because of the small number of female students in the study, it is difficult to determine if the results for question two could have been skewed in one direction in favor of the male or female students.

Research question three was developed to determine if the students in the NXT Robotics elective class (treatment group) for attitude of science inquiry, enjoyment of science lessons, leisure interest in science, and career interest in science based on ethnicity. The different ethnic groups in the study were (1) White, non-Hispanic; (2) Black, non-Hispanic; (3) Hispanic; and (4) Asian or Pacific Islander. The 57 students in the treatment group were broken down by ethnicity into 27 White, non-Hispanic students; 24 Black, non-Hispanic students; 4 Hispanic students; and 2 Asian or Pacific Islander students. The attitude of science inquiry determined students' acceptance of science inquiry as a way of thought in their classes. The assumption of homogeneity of slopes was met and ANCOVA could be used. There was no significant difference in the adjusted means among the ethnic groups; therefore, the null hypothesis was retained. Because there was no significant difference among the ethnic groups, pairwise comparisons were not conducted. The enjoyment of science lessons determined the students' enjoyment of science learning experiences. The assumption of homogeneity of slopes (parallel slopes) was not violated and ANCOVA could be used. There was a significant difference in the adjusted means among the ethnic groups; the null hypothesis was rejected. The $F$ test was significant so the Tukey post hoc test was used to determine which pair of means were different. There was a significant difference between White, non-Hispanic students and Black, non-Hispanic students ($p = .001$). The adjusted mean for the White, non-Hispanic students was more than nine points higher than the mean for the Black, non-Hispanic students. No other pairs of adjusted means were significantly different. The leisure interest in science determined the students' development of interest in science and science-related activities. The assumption of homogeneity of slopes was met and ANCOVA could be used. There was a significant difference in the adjusted means among the ethnic groups; the null hypothesis was rejected. The $F$ test was significant so the Tukey post hoc test was used to determine which pair of means were different. There was a significant difference between White, non-Hispanic students and Black, non-Hispanic students ($p = .048$). The adjusted mean for the White, non-Hispanic students was more than six points higher than the mean for the Black, non-Hispanic students. No other pairs of adjusted means were significant. The career interest in science determined the students' development of interest in pursuing a career in science. The assumption of homogeneity of slopes was met and ANCOVA could be used. There was a significant difference in the adjusted means among the ethnic groups; the null hypothesis was rejected. The $F$ test was significant; the Tukey post hoc test was used to determine which pair of means were different. There was a significant difference between Black, non-Hispanic students and White, non-Hispanic students ($p$

= .001). The mean for Black, non-Hispanic students was significantly different from the mean for Hispanic students ($p = .036$). The mean for Black, non-Hispanic students was more than 9 points lower than the mean for White, non-Hispanic students and more than 12 points lower than the mean for Hispanic students. No other pairs of adjusted means were significantly different. The number of study participants was limited by federally-mandated class size regulations of the Carl Perkins Plan. There were only four Hispanic and two Asian or Pacific Islander students out of the 57 students in the study; this made it difficult to get an accurate picture of how ethnicity affects the NXT Robotics curriculum on high school students' attitudes about interest in science for Hispanic and Asian or Pacific Islander students. If the data collected were used to analyze the effects of the program on only White, non-Hispanic (52%) and Black, non-Hispanic (47%) students in the study, a more accurate ethnicity effect could be determined.

**Relationship to the Literature**

Pressure on schools from high-stakes testing affects the curriculum as well as classroom teaching methodologies (Passman, 2001). Some schools have changed their curricula to closely resemble the content of their individual state-mandated tests (Wolter-Gustafson, 2004). High-stakes testing, as a way of assessing the success of schools in educating students, is likely to continue in the future (United States Department of Education, 2002). High-stakes testing in the form of federally required standardized tests mandated by NCLB is a major event in secondary school classrooms because teachers devote much time to preparing students in the months that precede testing (Wolter-Gustafson, 2004). Because of increased accountability, high-stakes tests have become an indicator of the effectiveness of teachers and schools, resulting in an exaggerated emphasis on test results (Cizek, 2001; Ganesh, 2007).

The research has shown that teaching methodologies have changed since the implementation of NCLB (Bottoms & Anthony, 2005; Sullivan, 2006; Sunderman, et. al. 2004). The teachers of the NXT Robotics program are not required to administer mandated testing and have been able to take a team approach to curriculum interpretation and implementation for the benefit of the students in their classes. This has enabled them to be spontaneous, creative, and innovative thinkers in their classroom teaching. Jerald (2006) stated that some teachers, feeling pressure to maximize student test scores, have also changed the way they teach, placing greater focus on the structure of the test and test-taking strategies than on teaching strategies for higher order thinking.

The National Science Education Leadership Association (2010) said educators should be introducing students to scientific processes, probeware, computer data collection, and robotics in the elementary schools, not waiting for higher educational institutes to get students interested in STEM education. A successfully implemented STEM program is one that trains students to be critical thinkers and problem solvers by teaching them not just the scientific facts, but more importantly, the practices scientists and engineers use to understand the world and to draw conclusions based on evidence (Long, 2010).

There are two standard practices for teaching students: teacher directed and student centered. In a teacher-directed class, the teacher instructs while the students absorb the instruction. In a student-centered learning environment, a constructivist approach, cooperative groups and integrated curricula are used by the teacher to engage students. The NXT Robotics class was based on a student-centered learning approach in which students engage at different levels of learning (Gregory & Hammerson, 2008; Tomlinson, 2006). A recent report on United States' economic prospects in the 21$^{st}$ century, *Rising Above the Gathering Storm*, concluded that leadership in scientific endeavors was crucial to success. By extension, the report found it was necessary to vastly improve America's talent pool through science, mathematics, and technology education (Daniel, 2006). Dethlefs's (2002) study stated that there was a direct relationship between students working in corporative groups and their interests in school. The NXT Robotics class is a student-centered class where students move and advance at their own pace and have the ability to further investigate a topic surrounding robotics through STEM activities. This research study did not address whether the student-centered class had an impact on how the students advanced through the curriculum or if they were engaged in the self-paced learning community. If the study were to be duplicated, the students should have open-ended questions that gave them the chance to voice their opinion on the merits of the program.

Improving students' attitudes and interest in science is an important step in encouraging students to study the sciences beyond the required high school years (National Science Foundation, 2009). Research question two was used to determine if there was a difference in attitude of science inquiry, enjoyment of science lessons, leisure interest in science, or career interest in science by gender. The results of this study did show that there was little to no significant difference between how the males and females responded to the questions that measured attitude of science inquiry, enjoyment of science lessons, leisure interest in science, or career interest in science. There were 48 males and 9 females in the NXT Robotics class; the low number of females who participated in the study should prompt further investigation to determine if the program would have an impact on female high school students. It cannot be determined why the male and female students did not show a significant difference in their science attitudes. There were only nine female students in the study; could it be that these nine students were already interested in the sciences or did they take the class because of pervious experiences in robotics? These are questions that would need to be answered in a future study to receive a better picture as to why there was no significant difference in how the male and female students responded to the TOSRA. A future study could also be conducted to determine if the NXT Robotics program had a lasting effect on female students beyond the high school level of education.

Noble Prize-winning physicist Leon Lederman (2008) said that American students finish near dead last among those from developed countries in mathematics and science testing and that they are turned off at an early age (National Academy of Science, 2009). If students are turned off at an early age towards mathematics and science it is imperative that attitudes towards the sciences need to be changed. International students now earn 6 out of every 10 engineering doctorates at universities in the United States (National Academy of Science, 2009). One-third of undergraduates in the United States earn a degree in science and engineering, while nearly two-thirds of Chinese and Japanese students do (National Academy of Science, 2009). The topic of career interest in science, mathematics, engineering, and technology for high school students is something that needs to be addressed if the United States education system wants to produce more engineering students on the graduate level. Research question one was used to determine if there was a difference in how the students responded by grade level to the TOSRA. There was a significant difference in the enjoyment of science lessons between the 12$^{th}$ and 9$^{th}$ grade students. There was also a significant difference between the 12$^{th}$ and 10$^{th}$ grade students. It needs to be determined if there was difference because of the maturity level of the students in the NXT Robotics class or if the 12$^{th}$ grade students' adjusted scores were higher because they are thinking more towards their educational future? The career interest in science also showed a significant difference in adjusted means between the 9$^{th}$ and 11$^{th}$ grade and the 9$^{th}$ and 12$^{th}$ grade scores. Again this shows that the 9th grade students were less affected by the NXT Robotics class than the 11th and 12th grade students. One aspect that will need to be investigated is if the 9th grade students have not developed independent thinking and working skills that are needed in the NXT Robotics class.

Research question three analyzed ethnicity for the four different attitudes towards the sciences and there was a significant difference between the White, non-Hispanic and Black, non-Hispanic students for 3 of the 4; enjoyment of science lessons, leisure interest in science lessons, and career interest in science. According to Gabriel (2010), black males attend college far less than those of white males who graduate from high school. Cary (1995) stated that black high school students did not think of the potential of a career in the sciences because they had a lack of exposure to the sciences, which had to do with a low self-esteem. Cary went on to state that most U.S. educators tend to have the opinion that culturally diverse students are deficient. According to Addison and Westmoreland (1999), minority students should be allowed to work with their hands on projects and move about the room when learning. The NXT Robotics class did provide this type of learning environment for all the students in the class. So why did the black students still score lower on the TOSRA? The robotics class is a student centered learning environment where students are encouraged to move about the class and share their learning activities with other students. Minority students in turn should have thrived in the NXT Robotics class, yet they score significantly lower than the majority students. Addison and Westmoreland (1999) stated that minority students use a learning style that is inconsistent with students in the majority culture. Therefore, it must be determined how the NXT Robotics program can be improve and better structured to meet the needs of minority students.

## Limitations and Recommendations

One limitation of the study was the small number of students examined. This occurred because of class size enrollment restrictions set forth by the federally funded Carl Perkins grant. The results of this study were based on a limited population, three NXT Robotics classes held in the spring 2010 semester. Due to the population size, it was not viable to eliminate outliers from the data. A larger population would have allowed for the removal of outliers from the data. The subjects were part of an intact group of students without randomization of selection. The sample size was limited to the students who signed up to take the NXT Robotics class. Classes are filled on a first-registered basis; the sample size of the class was 57 students, of whom only nine were female. The ethnicity of the research subjects was also limited to the students enrolled in the class, which led to only four Hispanic and two Asian or Pacific Islander subjects out of a total of 57 students in the treatment group. With a research study of this size, there was not a diverse enough population to analyze how the ethnicity of the students was affected by the NXT Robotics curriculum. Another limitation was that the teachers had a set curriculum and pacing guide to shape their lesson plans but they did have the authority to revise the curriculum to fit the needs of each individual student. This limited any control the researcher had over how the curriculum was presented to accommodate the individual students' needs in the class.

The current study is significant because it attempted to determine the effectiveness of the NXT Robotics curriculum that has been implemented in a rural school division on the secondary level. The program attempted to improve high school students' attitudes and interests in science. Future research should incorporate all students enrolled in the NXT Robotics class for an entire school year, not just one semester. This study could be repeated with a larger and more varied sample size. A larger sample size could be obtained through cooperative research with other high schools that use a similar curriculum and prepared lesson plans.

Another recommendation for additional research would be to interview individual students following submission of the posttest to get a better understanding of how the NXT Robotics class affected student's attitudes and interest in science. Interview questions might include the following: How has taking the NXT Robotics class altered your attitude towards science, influenced your career goals, influenced your decision of possible college selections, or affected your views on education; or name the one thing you discovered about yourself by being involved in the NXT Robotics class? This additional qualitative analysis could be utilized to review whether the curriculum is appropriate for students in all grade levels or if students should be placed in different NXT Robotic classes depending on their age and grade level.

**Conclusion**

This study was conducted to determine what effect the NXT Robotics class had on a student's perception of science attitude and interest. A total of 114 students participated in a pretest and posttest survey, 57 of the students completed an 18-week semester long elective NXT Robotics class (treatment group), and 57 students participated in a core science class (control group). The object of the study was to determine if the students who participated in the NXT Robotics class had a more positive attitude or interest towards science after completing the class and whether the class encouraged those students to pursue more science-based extracurricular activities.

With the current budget crisis, it is imperative that school districts invest their resources efficiently, meaning that school districts should invest in programs that produce the intended effect. Students who have positive science learning experiences close to college enrollment may be more inclined to major in science-related subjects at the postsecondary level. The results of this survey will allow teachers and administrators to investigate how the NXT Robotics program could be altered to make it more effective. It will also allow the teachers to evaluate the methods they used for teaching the material, to revise the curriculum, and to determine technology to fit the needs of individual students. Some teachers feel pressure to change the way they teach in order to improve student outcomes on standardized tests, resulting in conflict with their philosophy of education and their knowledge of the advantages of a student-centered learning environment.

Finally, it might spur on other technological or scientific-based industries to develop their own special curriculum to be implemented in schools. Many of the STEM industries complain how few students are graduating with STEM degrees, ultimately leaving these industries with many open jobs and few qualified applicants. However, few (if any) of these industries have taken the necessary steps to secure their future workforce by implementing programs to encourage students' interest in STEM-related areas. In reality, with a recent boom in new technological and science-based jobs, these industries are best situated to explain to students what they do and what the benefits are to pursuing a STEM-based career. Further investigation by the educational staff will have to be completed in order to determine if changes in the curriculum in the NXT Robotics class would improve the attitudes and interests of students in the program. The hope is that this study will spur changes in current science curriculum by showing school districts that their "teaching the test" approach is not effective at inspiring and encouraging young minds and that students would be better served educationally by allowing teachers to implement interesting and creative strategies into their daily curriculum.

References

Aboud, F., & Doyle, A. (1993). The early development of ethnic identity and attitudes. In M. E. Bernal & G. P. Knight (Eds.), *Ethnic identity: Formation and transmission among Hispanics and other minorities* (pp. 31-46). Albany, NY: State University of New York Press.

Abrams, I. M., & Madaus, G. F. (2003). The lessons of high-stakes testing. *Educational Leadership*, *61*(32), 31-35.

Addison, M. M., & Westmoreland, D. A. (1999). African American male students in the classroom: Identification, motivation, retention. In W. G. Harris & G. M. Duhon (Eds.), *The African American male perspective of barriers to success* (pp. 7-60). New York, NY: Edwin Mellen Press.

Adolphe, F. (2002). *A cross-national study of classroom environment and attitudes among junior secondary science students in Australia and Indonesia* (Doctoral dissertation, Curtin University of Technology). Retrieved from http://adt.curtin.edu.au/theses/available/adt-WCU20031201.141540.

Akinoglu, O. & Tandogan, O. (2007). The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Journal of Mathematics, Science & Technology Education* (3), 71-80.

Aldridge, J. M. & Fraser, B. J. (2000). A cross-national study of classroom environments in Taiwan and Australia. *Learning Environments Research: An International Journal* (3), 24-29.

Allen, L. (2008) *The Young inventor's project with LEGO mindstorm education nxt &*

*LEGO mindstorm nxt software.* Vision Education and Media. New York, NY.

American Association for the Advancement of Science. (2004). *Invention and impact: Building excellence in undergraduate science, technology, engineering and mathematics education.* Washington, DC: Project 2061.

American Geological Institute. (2004). Women and minorities in science. Retrieved from http://www.agiweb.org/gap/legis/womenscience

Arroyo, C. G., & Zigler, E. (1995). Racial identity, academic achievement, and the psychological well-being of economically disadvantaged adolescents. *Journal of Personality and Social Psychology, 69*(5), 903-914.

Ary, D., Jacobs, L., Razavieh, A., & Sorensen, C. (2006). *Introduction to research in education.* Blemont, Canada: Thomson/Wadsworth.

Atwater, M. (1989). Including multicultural education in science education: Definitions, competencies and activities. *Journal of Science Teacher Education, 1*(1), 17-20.

Bernal, M., Knight, G., Ocampo, K., Garza, C., & Cota, M. (1993). Development of Mexican American identity. In M. E. Bernal & G. P. Knight (Eds.), *Ethnic identity: Formation and transmission among Hispanics and other minorities* (pp. 31-46). Albany, NY: State University of New York Press.

Berube, C. T. (2004). Are standards preventing good teaching? *Clearing House, 77*(6), 264-267.

Blake, H. (2010). Apollo 11 moon landing: Neil Armstrong and Buzz Aldrin split over Mars. *The Telegraph*. Retrieved from http://www.telegraph.co.uk/science/space/5849485/Apollo-11-Moon-landing-Neil-Armstrong-and-Buzz-Aldrin-split-over-Mars.html

Bottoms, G., & Anthony, K. S. (2005). *Project lead the way: A pre-engineering curriculum that works: A new design for high school career, technical studies.* Atlanta, GA: Southern Regional Education Board.

Boyd, V. S., Hunt, P. F., Kandell, J. J., & Lucas, M. S. (2003). Relationship between identity processing style and academic success in undergraduate students. *Journal of College Student Development, 44*(2), 155-167.

Career and Technology Education program (CTE). (2010). *CTE resource center*. Retrieved from http://www.acteonline.org/erc.aspx

Carey, P. (1995). Saluting the past, shaping the future. *Black Enterprise,* 140.

Carnegie Mellon Robotics Curriculum Website. (2010). *Robotics curriculum.* Retrieved from http://www.rec.ri.cmu.edu/education/roboticscurricuulm/

Cavallo, A. M., & Laubach, T. A. (2001). Students' science perceptions and enrollment decisions in differing learning cycle classrooms. *Journal of Research in Science Teaching*, *38*, 1025-1062.

Center for Engineering Education Outreach (CEEO) at Tufts University. (2010). *Robotics in engineering.* Retrieved from http://www.ceeo.tufts.edu

Chavous, T. M., Bernat, D. H., Schmeelk-Cone, K., Caldwell, C. H., Kohn-Wood, L., & Zimmerman, M. A. (2003). Racial identity and academic attainment among African American adolescents. *Child Development, 74*(4), 1076-1090.

Cizek, C. J. (2001). More unintended consequences of high-stakes testing. *Educational Measurement, Issues and Practices, 20*(4), 19.

Committee on Science, Engineering, and Public Policy. (2006). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*. Washington, DC: National Academies Press.

Cooper, C. (2006). High-stakes assessment: What bright students are losing? *Parenting For High Potential.*

County Public Schools (2010). StarStudent database for students enrolled in the NXT Robotics class (for demographics used in this study).

Cross, T., & Slater, R. B. (2000). The alarming decline in the academic performance of African-American men. *Journal of Blacks in Higher Education*, *27*, 82-87.

CTE's Role in Science, Technology, Engineering and Math. (2009). *Issue Brief. Association for Career and Technology Education (ACTE).* Retrieved from http://www.acteonline.org/

Daniel, A. (2006, October). American Society for Engineering Education. *ASEE PRISM 16*(2). Retrieved from http://prismmagazine.org/oct06/print_friendly.php?url=www%2Eprism%2Dmaga

Delpit, L. (1992). Education in a multicultural society. Our future's greatest challenge. *Journal of Negro Education*, *61*(3), 237-249.

Department of Education in Virginia. (2009). *Virginia, Standards of Learning (SOL*). Retrieved from http://www.doe.virginia.gov/testing/index.shtml

Dethlefs, T. M. (2002). Relationship of constructivist learning environment to student attitudes and achievement in high school mathematics and science. *Dissertation Abstracts International*, *63*(07), 2455.

Dhindsa, H. S., & Chung, G. (2003). Attitudes and achievement of science students.

*International Journal of Science Education,* 25, 5-12.

Diamond, M., & Hobson, J. (1998). *Magic trees of the mind*. New York, NY: Penguin.

Duncan, A. (2010). U.S. Education Secretary at the Emerging Issues Forum. Retrieved from http://www.newsobserver.com/news/story/328723.html

Erikson, E. (1968). *Identity: Youth and crisis.* New York, NY: W. W. Norton & Company.

Farmer, H. S., Wardrop, J. L., & Rotella, S. C. (1999). Antecedent factors differentiating women and men in science/non-science careers. *Psychology of Women Quarterly,* 23, 763-780.

Feng, Z., Diehr, P., Perterson, A., & McLerran, D. (2001). Selected statistical issues in group randomized trials. *Annual Review of Public Health* (22), 167-187.

Fisher, D. L. & Waldrip, B. G. (1999). Cultural factors of science classroom learning environments, teacher-student interactions and student outcomes. *Research in Science and Technological Education, 17.*

Fitzmaurice, G. M., Laired, N. M., & Ware, J. H. (2004). *Applied longitudinal analysis*. Hoboken, N.J: Wiley.

Fraas, J. W. & Newman, I. (1997). *The use of the Johnson-Neyman confidence bands and multiple regression models to investigate interaction effects: Important tools for educational researcher and program evaluators.* Retrieved from http://www.eric.ed.gov/ERICDocs/data/ericdocs2sql/content_storage_01/000001

Fraser, B. J. (1978). Development of a test of science-related attitudes. *Science Education,* 62, 509-515.

Fraser, B. J. (1981). *TOSRA: Test of science-related attitudes handbook.* Hawthorn, Australia: Australian Council for Educational Research.

Gabriel, T. (2010) Proficiency of black students is found to be far lower than expected. *The New York Times.* Retrieved from http://www.nytimes.com/2010/11/09/education/09gap.html?intemail1

Ganesh, A. (2007). *The impact of standardized testing on teachers' pedagogy.* Teacher education yearbook, 15. Lanham, MD: Rowman & Littlefield Education.

Genalo, L. J., Schmidt, D. A., Schiltz, M. (2004) Piaget and engineering education. *Proceedings of the American Society for Engineering Education Annual Conference and Exposition*. New York, NY.

George, R. (2000). Measuring change in students' attitudes toward science over time: An application of latent variable growth modeling. *Journal of Science Education and Technology, 9*, 213-225.

George, R., & Kaplan, D. (1998). A structural model of parent and teacher influences on science attitudes of eighth graders: Evidence from NELS: 88. *Science Education*, *82*, 93-109.

Germann, P. J. (1988). Development of the attitude toward science in school assessment and its use to investigate the relationship between science achievement and attitude toward science in school. *Journal of Research in Science Teaching,* 25, 689-703.

Givens, B. K. (2002). *Teaching to the brain's natural learning systems*. Alexandria, VA: Association for Supervision and Curriculum Development.

Glatthorn, A. A., & Joyner, R. L. (2005). Writing the winning thesis or dissertation: A step by step guide (2nd ed.). Corwin Press. New York, NY.

Gregory, G. H., & Chapman, C. (2007). *Differentiated instructional strategies: One size doesn't fit all* (2nd ed.). Thousand Oaks, CA: Corwin Press.

Gregory G., & Hammerman, E. (2008). *Differentiated instructional strategies for science grades k-8.* Thousand Oaks, CA: Corwin Press.

Griffith, D. S. (2005). *FIRST Robotics as a model for experiential problem-based learning: A comparison of student attitudes and interests in science, mathematics, engineering, and technology*. (Doctoral dissertation) Clemson University (Publication No. AAT 3170164).

Gunzenhauser, M. G. (2003). High-stakes testing and the default philosophy of education. *Theory into Practice* (42), 1. Retrieved from http://muse.jhu.edu/journals/theory_into_practice/v042/42.1gunzenhauser.pdf

Gupta, J. K., Srivastave, A. B., & Sharma, K. K. (1988). On the optimum predictive potential of change measures. *Journal of Experimental Education, 56*, 124-128.

Haladyna, T., & Shaughnessy, J. (1982). Attitude towards science: A quantitative synthesis. *Science Education*, *66*, 547-563.

Harmer, A. J., & Cates, W. M. (2007). Designing for learner engagement in middle school science: Technology, inquiry, and the hierarchies of engagement. *Computers in the Schools*, *24*, 105-120.

Helms, J. E. (1990). *Black and white racial identity: Theory, research, and practice*. New York, NY: Greenwood Press.

Henderson, D., & Reid, K. (2000, January). *Learning environments in senior secondary science classes.* Paper presented at the second international conference of Science, Mathematics, Technology Education, Taipei, Taiwan.

Heubert, J., & Hauser, R. (Eds.). (1999). *High-stakes: Testing for tracking, promotion, and graduation.* Washington, DC: National Academy Press.

Hill, O. W., Pettus, W. C., & Hedin. B. A. (1990). Three studies of factors affecting the attitudes of blacks and females toward the pursuit of science and science-related careers. *Journal of Research in Science Teaching, 27*, 289-314.

Hoffman, J. V., Assaf, L. C., & Paris, S. G. (2001). High-stakes testing in reading: Today in Texas, tomorrow? *The Reading Teacher, 54*(5), 482-494.

International Reading Association. (2009). Information and Communication Technologies (ICT). *New Literacies and 21st Century Technologies position statement.* Retrieved from http://www.reading.org/General/AboutIRA/PositionStatements/21stCenturyLiteracies.asp

Jamieson, S. (2004). Likert scales: How to (ab)use them. *Medical Education*, *38*,1212-1218. Retrieved from. http://www.mededuc.com/articles/toptenarticles/ILikertScales.pdf

Jarvis, T., & Pell, A. (2002). Changes in primary boys and girls attitudes to school and science during a two-year science in-service program. *Curriculum Journal* (13).

Jawaharial, M., Larriva, C., & Nemiro, J., (2007). School robotics initiative – An outreach initiative to prepare teachers and inspire students to choose a career in engineering and science. *Proceedings of the 2007 American Society of Engineering Education Pacific Southwest Annual Conference*.

Jensen, E. (1998). *Teaching with the brain in mind.* Alexandria, VA: Association for Supervision and Curriculum Development.

Jerald, C. (2006) *Teach to the test? Just say no.* Issue Brief. Center for Comprehensive School Reform and Improvement. (ERIC Document Reproduction Service No.

ED494086).

Jones, M. G., Howe, A., & Rua, M. (2000). Gender differences in students' experiences, interests, and attitudes towards science and scientists. *Science Education* (84).

Kamen, D. (2009). Founder of FIRST, thought leaders, the mind of the innovator. *Forbes.com.* Retrieved from http://www.forbes.com/2009/07/30/dean-kamen-thought-leaders-transcript.html

Kanai, K., & Norman, J. (1997). Systemic reform evaluation: Gender differences in student attitudes towards science and mathematics. *Association for the Education of Teachers, 97*, 26.

Kazmierczak, M. F., & James, J. (2005). *Losing the competitive advantage? The challenges for science and technology in the United States*. Washington, DC: American Electronics Association.

Khalili, K. Y. (1984). *Factors related to science enrollment and literacy in a particular American high school district*. (Doctoral dissertation) University of Illinois (Publication No. AAT8422099).

Koretz, D., Linn, R. L., Dunbar, S. B., & Shepard, L. (1991, April). *The effects of high-stakes testing on achievement: Preliminary findings about generalization across tests*. Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Lau, P., McNamara, S., Rogers, C., & Portsmore, M. (2001) LEGO Robotics in engineering. *Proceedings of the America Society for Engineering Education Annual Conference and Exposition*.

Lee, O. (2001). Culture and language in science education: What do we know and what do we need to know? *Journal of Research in Science Teaching, 38*, 499-501.

LEGO Education (2006-2010). *Company Profile.* An introduction to the LEGO group by Corporate Communications.

Lewis, L., & Farris, E. (1996). *Remedial education at higher education institutions in fall 1995* (NCES 97, 584). Washington, DC: U.S. Department of Education, National Center for Education Statistics..

Linn, R. L., Baker, E. L., & Betebenner, D. W. (2002). Accountability systems: Implications of requirements of the No Child Left Behind Act of 2001. *Educational Researcher, 31*, 3-16.

Linn, R. L., & Slinde, J. A. (1977). The determination of the significance of change between pre and post testing periods. *Review of Educational Research, 47*, 121-150.

Long, D., (2010). STEM education can help prevent the next disaster. *District Administration,* July/August (23).

Mahoney, M., (2009). *Student attitude toward stem: Development of an instrument for high school stem-based program*. (Doctoral dissertation). Ohio State University (Publication No. 7522009).

Maxwell, S. E., & Delaney, H. D. (1990). *Designing experiments and analyzing data: A model comparison perspective.* Pacific Grove, CA: Brooks/Cole.

McMillian, J. H., Myran, S., & Workman, D., (1999) *The impact of mandated statewide testing on teachers' classroom assessment and instructional practices.* Richmond, VA: Metropolitan Educational Research Consortium. (ERIC Document Reproduction Service No. ED431041).

Moon, T. R., Brighton, C. M., & Callahan, C. M.. (2003) State standardized testing programs: Friend or foe of gifted education? *Roeper Review, 25*(2), 49-60.

Morrell, P. D., & Lederman, N. G. (1998). Students' attitudes toward school and classroom science: Are they independent phenomena? *School Science and Mathematics, 98*, 76-83.

Mullis, I. V., Martin, M. O., & Foy, P. (2008). *TIMSS 2007 international mathematics report: Findings from IEA's trends in international mathematics and science study at the fourth and eighth grades*. Chestnut Hill, MA: TIMSS & PIRLS International Studies.

National Academy of Science (2009, September 10). K-12 education should include engineering, experts say. *ScienceDaily.* Retrieved from http://www.sciencedaily.com/releases/2009/09/090908125129.htm

National Center for Education Statistics (NCES). (2000). *Educational equity of girls and women.* Retrieved from http://nces.ed.gov/2000

National Center for Education Statistics (NCES). (2003). *Education stats at a glance: Condition of education 2000-2004*. Retrieved from http://nces.ed.gov/2000_2004

National Center for Education Statistics (NCES). (2006). The national report card: Science 2005. Retrieved from http://nces.ed.gov.science2005

National Education Goals Panel, (1997). *The national education goals panel, volume one: The national report 1997.* Washington DC: Government Printing Office.

National Institutes of Health Office of Science Education, National Institute of General Medical Sciences, and Biological Science Curriculum Study (NIH). (2006). *Doing science – The process of scientific inquiry.* Washington, DC: Government Printing Office.

National Science Board (2004). Science and engineering indicators 2004. Science and technology: Public attitudes and understanding highlights. Retrieved from http://www.nsf.gov/statistics/seind04/c7

National Science Foundation (2009). Division of Science Resources Statistics. *Women, minorities, and persons with disabilities in science and engineering* (NSF Publication No. 09-205). Retrieved from http://www.nsf.gov/statistics/wmpd.

National Science Teacher Association. (2010). PISA report shows U.S. progress. Retrieved from http://science.nsta.org/nstaexpress/nstaexpress_2010_12_13_pisa_nonmember

Ndakwah, E. A. (2006). *Gender differences in tenth-grade students' attitudes towards science: The effect of school type* (Doctoral dissertation). Retrieved from http://proquest.umi.com.ezproxy.liberty.edu:2048/pdweb?SQ

Newson, J. T. (2011). School of community health, Portland State University. *Types of scales & levels of measurement.* Retrieved from http://www.upa.pdx.edu/IOA/newsom/defaulty.htm

Norman, G., (2010). *Likert scales, levels of measurement and the laws of statistics.* Methodologist's Corner. McMaster University. Retrieved from http://xa.yimg.com/kq/groups/18751725/1039265037/name/Likert+scales,+levels+of+measurement+and+the+laws.pdf

North Central Regional Educational Laboratory (NCREL). (2003). *enGauge 21st century skills: Educational literacy in digital age.* Retrieved from http://www.ncrel.org/engauge/skills/engauge21st.pdf.

Nummedal, S. G., (1986). *Developing reasoning skills in college students, applications of cognitive psychology: problem solving, education, and computing*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Oakes, J. M., & Feldman, H. A. (2001). Statistical power for nonequivalent pretest-posttest designs: The impact of change-score versus ANCOVA models. *Evaluation Review, 25*, 3-28.

Obama, B. (2009). *Signing of stem cell executive order and scientific integrity presidential memorandum*. Retrieved from http://www.whitehouse.gov/the_press_office/remarks-of-the-president-as-prepared-for-delivery-signing-of-stem-cell-executive-order-and-scientific-integrity-presidential-memorandum/

Office of Science and Technology Policy (OSTP). (2009). Executive Office of the President. Retrieved from http://www.ostp.gov/cs/issues/overview

Ornstein, A. (2006). The frequency of hands-on experimentation and student attitudes towards science: A statistically significant relation. *Journal of Science Education and Technology, 15*, 285-297.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implication. *International Journal of Science Education, 25*, 1049-1079.

Pang, V. O. (1994). Why do we need this class? *Multicultural Education for Teachers*. Phi Delta Kappa, 289-292.

Papanastasiou, C., & Papanastasiou, E. (2004). Major influences on attitudes towards science, *Educational Research and Education*, *10*, 239-257.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York, NY: Basic Books.

Papert, S. (1993) *The children's machine: Rethinking school in the age of the computer.* New York, NY: Basic Books.

Passmore, R. (2001). Experiences with student-centered teaching and learning in high-stakes assessment environments. *Education, 122*(1), 189.

Pell, A., & Jarvis, T. (2003). Developing attitude to science education scales for use with primary teachers. *Journal of Science Education*, *25*, 1273-1295.

Phinney, J. (1993). A three stage model of ethnic identity development in adolescence. In M. E. Bernal & G. P. Knight (Eds.), *Ethnic identity: Formation and transmission among Hispanics and other minorities* (pp. 31-46). Albany, NY: State University of New York Press.

Piaget, J., (1980). *Adaptation and intelligence.* Chicago, IL: University of Chicago Press.

Preacher, K. J., Curran, P. J, & Bauer, D. J. (2006, Winter). Computational tools for probing interactions in multiple linear regression, multileveled modeling, and latent curve analysis. *Journal of Educational and Behavioral Statistics*. 31, (4) 437-448.

Quigley, W. P. (2001). *Due process rights of grade school students subjected to high stakes testing.* 10 B.U. Pub. Int. L.J. 284 Loyola University New Orleans College of Law.

Rachor, R. E., & Cizel, G. J. (1996). Reliability of raw gain, residual gain, and estimated true gain scores. Retrieved from http://www.eric.ed.gov/ERICWebPortal/search/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=ED398269&ERICExtSearch_SearchType_0=no&accno=ED398269

Robotics Academy. (2008-2010). *Robotics curriculum.* Retrieved from http://www.education.rec.ri.cmu.edu/

Rogers, C. (2006). Bringing engineering to elementary school. *Journal of STEM Education, 5*, 3-4.

Rogosa, D. (1988). *Methodological issues in aging research.* New York, NY: Springer.

Schibeci, R. A., & Riley, J. P. (1986). Influence of students' background and perceptions on science attitudes and achievements. *Journal of Research in Science Teaching, 23*, 177-187.

Schlechty, P. C., (2002). *Working on the work: An action plan for teachers, principals, and superintendents.* San Francisco, CA: Josey-Bass.

Sloane, F. C., & Kelly, A. E. (2003). Issues in high-stakes testing programs. *Theory into Practice (42)*1, 12-17.

Smith, E. P., Walker, K., Fields, L., Brookins, C., & Seay, R. (1999). Ethnic identity and its relationship to self-esteem, perceived efficacy and pro-social attitudes in early adolescence. *Journal of Adolescence, 22,* 867-880.

Smolkowski, K. (2010). *Gain Score Analysis.* Retrieved from Oregon Research Institute website: www.ori.org/keiths/files/tips/stats_gainscores.html.

Stecher, B. M., Barron, S., Chun, T., & Ross, K. (2000). *The effects of the Washington state education reform on schools and classrooms* (CSE Tech. Rep. No. 525). Los Angeles, CA: University of California.

Stecher, B. M., & Hamilton, L. S. (2002). Putting theory to the test: Systems of "educational accountability" should be held accountable. *Rand Review, 26*(1), 16-23.

Stephens, R. (2010). Testimony to the House Science and Technology Committee. Senior Vice President, Human Resources and Administration. The Boeing Company and Chairman Aerospace Industries. February 4, 2010.

Sullivan, G. P. (2006). *The impact of high-stakes testing on curriculum, teaching, and learning* (Doctoral dissertation). Available from Virginia. Dissertation & Theses: Full Text database.

Sunderman, G. L., Tracey, C. A., Kim, J., & Orfield, G. (2004). *Listening to teachers: Classroom realities and No Child Left Behind.* Cambridge, MA: The Civil Rights Project at Harvard University.

*Tapping American's Potential: The education for innovation initiative: The warning signs.* (2005). Washington, DC: Business Roundtable.

Tatum, B. D. (1999). *Why are all the black kids sitting together in the cafeteria?* New York, NY: Basic Books.

Taylor, G., Shepard, L., Kinner, F., & Rosenthal, J. (2003). *A survey of teachers' perspectives on high-stakes testing in Colorado: What gets taught, what gets lost* (CSE Technical Report 588). Los Angeles, CA: University of California, National Center for Research on Evaluation, Standards, and Student Testing.

Thom, M. (2001). *Balancing the equation: Where are women and girls in science, engineering and technology?* New York, NY: National Council for Research on Women.

Thurlow, M. L., & Johnson, D. R. (2005). High-stakes testing of students with disabilities. *Journal of Teacher Education, 51*(4), 305-314.

Tomlinson, C. A. (2006). Invitations to learn differentiated instruction. Retrieved from http://www.nvcc.edu/loudoun/CTE/id62.htm

Trochim, W. (2000). *The research methods knowledge base* (2nd ed.) Cincinnati, OH: Atomic Dog Publishing.

Twaddle, S. S. (2010). Dissertation statistics professional. Johnson City, TN.

United Stated Department of Education, (2002). *No child left behind act of 2001*. Retrieved from http://www.ed.gov/policy/elsec/leg/esea02/107-110.pdf

United States Department of Education, (2009). Students who study science, technology, engineering and mathematics (STEM). Retrieved from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2009161

U.S. FIRST. (2006). *About FIRST.* Retrieved from FIRST Robotics Team Information website: http://www.usfirst.org/about/

U.S. FIRST. (2009). *About FIRST*. Retrieved from FIRST Robotics Team Information website: http://www.usfirst.org/about .

Varnado, T., (2005). *The effects of a technological problem solving activity on FIRST LEGO league participants' problem solving style and performance* (Doctoral dissertation). Retrieved from Virginia Tech. Full Text database.

Virginia Commonwealth University. (10/04/2001). Americans welcome scientific advancements with caution. *VCU News*. Retrieved from http://www.vcu.edu/uns/releases/2001/oct/

Welch, A. G. (2007). *The effect of the FIRST Robotics Competition on high school students' attitudes toward science* (Doctoral dissertation). Retrieved from

(Publication No AAT 3283939).

Wolter-Gustafson, M. (2004). Why I will not become a teacher. *Teacher Education Quarterly, 31*(4), 85-90.

Ysseldyke, J., Dennison, A., & Nelson, R. (2003). *Large-scale assessment and accountability systems: Positive consequences for students with disabilities.* (Synthesis Report 51). Retrieved from National Center on Educational Outcomes website: http://education.umn.edu/NCEO/OnlinePubs/Synthesis51.html

Ysseldyke, J., Nelson, J. R., Christenson, S., Johnson, D. R., Dennison, A., & Triezenberg, H. (2004). What we know and need to know about the consequences of high-stakes testing for students with disabilities. *Exceptional Children, 71*, 75-94.

Zacharia, Z., & Barton, A. C. (2004). Urban middle school students' attitudes toward science. *Science Education*, *88*(2),197-222.

Zimmerman, D. W., & Williams, R. H. (1982). Gain scores in research can be highly reliable. *Journal of Education Measurement*, *19*, 149-154.

APPENDICES

APPENDIX A

**Test of Science Related Attitudes (TOSRA)**
THE EFFECT OF THE NXT ROBOTIC CURRICULUM ON HIGH SCHOOL STUDENTS' ATTITUDES IN SCIENCE BASED ON GRADE, GENDER, AND ETHNICITY

Course Survey

**Directions:**

1. This test contains a number of statements about science. You will be asked what you think about these statements. There are no "right" or "wrong" answers. Your opinion is what is wanted.
2. For each statement, draw a circle around the specific numeric value corresponding to how you feel about each statement. **Please circle only ONE value per statement.**
   5 = Strongly Agree (SA)
   4 = Agree (A)
   3 = Uncertain (U)
   2 = Disagree (D)
   1 = Strongly Disagree (SD)

| **Statement** | **SA** | **A** | **U** | **D** | **SD** |
|---|---|---|---|---|---|
| 1. I would prefer to find out why something happens by doing an experiment more than by being told. | 5 | 4 | 3 | 2 | 1 |
| 2. Science lessons are fun. | 5 | 4 | 3 | 2 | 1 |
| 3. I would like to belong to a science club. | 5 | 4 | 3 | 2 | 1 |
| 4. I would dislike being a scientist after I leave school. | 5 | 4 | 3 | 2 | 1 |
| 5. Doing experiments is not as good as finding out information from teachers. | 5 | 4 | 3 | 2 | 1 |
| 6. I dislike science lessons. | 5 | 4 | 3 | 2 | 1 |
| 7. I get bored when watching science programs on TV at home. | 5 | 4 | 3 | 2 | 1 |
| 8. When I leave school, I would like to work with people who make discoveries in science. | 5 | 4 | 3 | 2 | 1 |
| 9. I would prefer to do experiments rather than to read about them. | 5 | 4 | 3 | 2 | 1 |
| 10. School should have more science lessons each week. | 5 | 4 | 3 | 2 | 1 |
| 11. I would like to be given a science book or a piece of science equipment as a present. | 5 | 4 | 3 | 2 | 1 |
| 12. I would dislike a job in a science laboratory after I leave school. | 5 | 4 | 3 | 2 | 1 |
| 13. I would rather agree with other people than do an experiment to find out for myself. | 5 | 4 | 3 | 2 | 1 |

| Statement | SA | A | U | D | SD |
|---|---|---|---|---|---|
| 14. Science lessons bore me. | 5 | 4 | 3 | 2 | 1 |
| 15. I dislike reading books about science during my holidays. | 5 | 4 | 3 | 2 | 1 |
| 16. Working in a science laboratory would be an interesting way to earn a living. | 5 | 4 | 3 | 2 | 1 |
| 17. I would prefer to do my own experiments rather than to find out information from a teacher. | 5 | 4 | 3 | 2 | 1 |
| 18. Science is one of the most interesting school subjects. | 5 | 4 | 3 | 2 | 1 |
| 19. I would like to do science experiments at home. | 5 | 4 | 3 | 2 | 1 |
| 20. A career in science would be dull and boring. | 5 | 4 | 3 | 2 | 1 |
| 21. I would rather find out things by asking an expert than by doing an experiment. | 5 | 4 | 3 | 2 | 1 |
| 22. Science lessons are a waste of time. | 5 | 4 | 3 | 2 | 1 |
| 23. Talking to my friends about science after school would be boring. | 5 | 4 | 3 | 2 | 1 |
| 24. I would like to teach science when I leave school. | 5 | 4 | 3 | 2 | 1 |
| 25. I would rather solve a problem by doing an experiment than be told the answer. | 5 | 4 | 3 | 2 | 1 |
| 26. I really enjoy going to science lessons. | 5 | 4 | 3 | 2 | 1 |
| 27. I would enjoy having a job in a science laboratory during my school holidays. | 5 | 4 | 3 | 2 | 1 |
| 28. A job as a scientist would be boring. | 5 | 4 | 3 | 2 | 1 |
| 29. It is better to ask a teacher the answer than to find it out by doing experiments. | 5 | 4 | 3 | 2 | 1 |
| 30. The material covered in science lessons is uninteresting. | 5 | 4 | 3 | 2 | 1 |
| 31. Listening to talk about science on the radio would be boring. | 5 | 4 | 3 | 2 | 1 |
| 32. A job as a scientist would be interesting. | 5 | 4 | 3 | 2 | 1 |
| 33. I would prefer to do an experiment on a topic than to read about it in science magazines. | 5 | 4 | 3 | 2 | 1 |
| 34. I look forward to science lessons. | 5 | 4 | 3 | 2 | 1 |
| 35. I would enjoy visiting a science museum on the weekend. | 5 | 4 | 3 | 2 | 1 |

| Statement | SA | A | U | D | SD |
|---|---|---|---|---|---|
| 36. I would dislike becoming a scientist because it requires too much education. | 5 | 4 | 3 | 2 | 1 |
| 37. It is better to be told scientific facts than to find them out from experiments. | 5 | 4 | 3 | 2 | 1 |
| 38. I would enjoy school more if there were no science lessons. | 5 | 4 | 3 | 2 | 1 |
| 39. I dislike reading newspaper articles about science. | 5 | 4 | 3 | 2 | 1 |
| 40. I would like to be a scientist when I leave school. | 5 | 4 | 3 | 2 | 1 |

41. What grade are you in? (circle your grade)

9 10 11 12

42. What is your gender? (check)

____ 1. Male
____ 2. Female

43. What is your ethnicity? (check one)

_____ 1. White, non-Hispanic
_____ 2. Black, non-Hispanic
_____ 3. Hispanic
_____ 4. Asian or Pacific Islander
_____ 5. American Indian or Alaskan Native
_____ 6. Other

APPENDIX B

# PARENTAL CONSENT FORM

**Please read this consent agreement carefully before you decide to allow your daughter/son to participate in this study.**

**Purpose of the research study:**

The purpose of this study is to investigate whether the NXT Robotics class has an effect on high school students' attitudes in science as compared to students who have not participated in the NXT Robotics course of study.

**What your child will do in the study:** Be informed about the study in a classroom at their high school, complete a 40-question survey during their NXT Robotics or science class.

**Time required:** The study will require about 20 minutes of your daughter/son's time, approximately 5 minutes to discuss, review, and sign the student assent form and 15 minutes to complete the survey.

**Risks:** There are no anticipated risks associated with participation in this study.

**Benefits:** There are no direct benefits to your daughter/son for participating in this research study. The study does have the potential to help [redacted] instruction department gain a better understanding of high school students' perception on their attitude and interest in the sciences.

**Confidentiality:** The information that your daughter/son provides in the study will be anonymous. Your daughter/son's name will not be collected or linked to the information s/he submits on the survey.

**Voluntary participation:** Your daughter/son's participation in the study is completely voluntary.

**Right to withdraw from the study:** Your daughter/son will have the right to withdraw from the study at any time without penalty.

**How to withdraw from the study:** If your daughter/son wants to withdraw from the study, s/he may stop completing the survey at any time and destroy it. There is no penalty for withdrawing.

**Payment:** Your daughter/son will receive no payment for participating in the study.

**If you have any questions about the study, contact:**

Researcher: Sandra Jewell
[redacted]

Faculty Advisor: Tracey Beno Pritchard
School of Education
Liberty University
tbpritchard@libery.edu

**Agreement:**

I agree to allow my child to participate in the research study described above.

Signature: _______________________________________________

Date: ____________________________

Parent/Guardian of: __________________________________
(Name of Student)

APPENDIX C

# STUDENT INFORMED ASSENT AGREEMENT

**Please read this consent agreement carefully before you decide to participate in the study.**

**Purpose of the research study:** The purpose of this study is to enhance change in the way that high school science students think about the sciences by bringing awareness that the sciences can be expanded beyond the basic standardized tests, and one avenue is the NXT Robotics class. Is the NXT Robotics class changing the attitude of high school students in the sciences?

**What you will do in the study:** Complete a 40 question survey after discussing it with your parent/guardian. The survey will be distributed to you in your high school NXT Robotics or science class. The survey will be taken during your class time.

**Time required:** The study will require about 20 minutes of your time, approximately 5 minutes to discuss, review, and sign the student assent form and 15 minutes to complete the survey.

**Risks:** There are no anticipated risks associated with participation in this study.

**Benefits:** There are no direct benefits for participating in this research study. The study does have the potential to help [redacted] instruction department gain a better understanding of high school students' perception on their attitude in the sciences.

**Confidentiality:** The information that you provides in the study will be anonymous. Your name will not be collected or linked to the information submitted on the survey.

**Voluntary participation:** Your participation in the study is completely voluntary.

**Right to withdraw from the study:** You have the right to withdraw from the study at any time without penalty.

**How to withdraw from the study:** If you want to withdraw from the study, you may stop completing the survey at any time and destroy it. There is no penalty for withdrawing.

**Payment:** You will receive no payment for participating in the study.

**If you have questions about the study, contact:**

Researcher: Sandra Jewell
[redacted]

Faculty Advisor; Tracey Beno Pritchard
School of Education
Liberty University
tbpritchard@libery.edu

**Agreement:**
I agree to participate in the research study described above.

Signature: ________________________________________ Date: ______________

APPENDIX D

March 14, 2010

[redacted]

Dear [redacted]

I am contacting you to ask for you consideration in allowing me to conduct a study at [redacted] to investigate whether the NXT Robotics class has an effect on high school students' attitudes in science compared to students who have not participated in the NXT Robotics course of study. I am seeking to determine if the NXT Robotics class is changing the attitude and interests of secondary students towards the sciences.

Specifically, I seek approval to distribute 60 surveys to the NXT Robotics students and 60 surveys to secondary science students at two [redacted]. The anonymous survey will require about 20 minutes of the students' time, approximately 5 minutes to discuss, review, and sign the student assent form and 15 minutes to complete the survey. Parent permission will be sought and acquired in writing prior to student assent and the completion of the surveys.

I have included the following documents for your review and consideration:

1. Parent consent form.
2. Student assent agreement.
3. The 40 item survey instrument titled Test of Science Related Attitudes (TOSRA).

Please note, the names of the [redacted] two high schools will be pseudonyms and will remain confidential and undisclosed. If there are particular elements of my request that need refinement or revision, please let me know, and I will make the required revisions. Additionally, my dissertation advisor, Dr. Tracey Pritchard can be contacted at tbpritchard@liberty.edu. I believe that the results of my research will be useful in efforts to determine the effectiveness of the NXT Robotics class at [redacted] and the influences it may have on students' attitudes and interest in the sciences.

Thank you for your consideration.
Sincerely,
Sandra Jewell
[redacted]
Doctoral Candidate, Liberty University School of Education

APPENDIX E

9/07 **RESEARCH EXEMPTION REQUEST** Ref. # __________

**Liberty University**

**Committee On The Use of Human Research Subjects**

---

1. Project Title: The effects of the NXT Robotics curriculum on high school students' attitudes in science based on grade, gender, and ethnicity

2. Please list all sources of funding. If no outside funding is used, state "unfunded":

Unfunded

3a. Principal Investigator(s) *[Must be a Liberty faculty member or investigator authorized by the Chair of the Institutional Review Board. If a student is the principal investigator, the student must have a faculty sponsor. Include contact information for both the student and the faculty sponsor as appropriate]*:

Sandra Lyn Jewell – Education Dissertation Student [redacted]

[redacted] sljewell@liberty.edu

Name and Title — Phone, E-mail, correspondence address

3b. Faculty Sponsor

302 437 4620

Tracey Pritchard — tbpritchard@liberty.edu

Name and Title — Dept., Phone, E-mail address

Anticipated Duration of Study: April 01, 2010 (From) June 01, 2010 (To)

4. Briefly describe the purpose of the study.

The purpose of this study is to investigate whether the NXT Robotics class has an effect on high school students' attitudes and interests in science as compared to students who have not participate in the NXT Robotics course of study.

5. Provide a lay language description of the procedures of the study. Address ethical issues involved in the study (See the Avoiding Pitfalls in section of the IRB website for helpful suggestions) and how you will handle them. For example, consider issues such as how

subject consent will be obtained (or explain why the study meets waiver guidelines for informed consent), how the data will be acquired, and how the data will be stored confidentially once it is collected. Please attach pertinent supporting documents: all questionnaires, survey instruments, interview questions and/or data collection instruments, consent forms, and any research proposal submitted for funding.

Sixty students in the NXT Robotics classes will be pre and post surveyed along with sixty science students that have not taken the NXT Robotics class. The students will be surveyed in their respective classes. The researcher is the science coordinator in the school division and will arrange and conduct the surveys. Voluntary consent forms will be sent home with students addressed to parents/guardians requesting permission for the student to participate in the survey. If permission is acquired the student's will also have a consent form to read and sign before the survey is given. The survey being used in this study is the Test of Science Related Attitudes (TOSRA). The research proposal does not require funding. After the students have conducted the surveys they will be stored with the researcher until after dissertation defense and then disposed of through shredding. A copy of the survey and parent consent form is attached. The surveys are anonymous and have no area that can be traced back to the students involved.

6. Will subject's data be gathered anonymously? YES X

7. Please describe the subjects you intend to recruit. For example, minors under age 18, adults 18 and over, students, etc. Also, please describe your recruitment procedures. How will you find participants for your study? How will you contact them? Please be explicit.:

The high school students enrolled in the NXT Robotics class are being surveyed with the consent of the parents. The demographic matching students (with NXT Robotics) that are enrolled in science classes will be surveyed with consent of parent. The science students will be selected to match the demographics of the students in the NXT Robotics class; age, gender, and ethnicity. If students/parents in either survey group do not want to fill out the survey they will not be required to. The students are 14–18 years of age in the 9th through 12th grade at the two public high schools in [redacted]

I have read the Human Subjects *"Research Exemption Request Guidelines"*.

Sandra Lyn Jewell — March 12 2010

Principal Investigator Signature(s) — Date

Tracey Pritchard — March 14, 2010

Faculty Sponsor (If applicable) — Date

---

**See application instructions for each above item below. Email form and supporting materials to fgarzon@liberty.edu. Also, submit a hard copy of the form and supporting materials to:**

**Dr. Fernando Garzon, IRB Chair, Campus North Suite 2400, 1971 University Blvd, Lynchburg, VA 24502**

---

**RESEARCH EXEMPTION REQUEST FORM INSTRUCTIONS FOR EACH ITEM**

1. **Project Title.** Please use the project title that is used in the application for funding. Please remain consistent in your use of the project title. A future change in the project title will require a completed Revision of Protocol Form.
2. **Funding Source.** All sources of funding should be listed. If no outside funding is used, state "unfunded." Please note whether funding is pending. If you have submitted a federal grant application for funding for this project, a copy of the grant application must be attached to the original of the submitted application.
3. **3.a: Principal Investigator(s).** The principal investigator (PI) must be a Liberty faculty member or investigator authorized by the IRB Chair. If a student is the principal investigator, a faculty sponsor is required and should be listed in 3b. Please provide each PI's name and contact information. **3.b.:** As needed, list the faculty sponsor's name and contact information. Much of the Committee's contact with the PI will be through e-mail. As such, it is important that the information be legible.
4. **Purpose of the Study.** Please describe in nonscientific terms the purpose of this study. In other words, why are you wanting to do this study (excluding degree requirement)?
5. **Specific procedures to be followed.** This should be a lay language description of the procedures of the study. Address ethical issues involved in the study (See Design Tips for helpful suggestions) and how you will handle them. Focus on issues such as how subject consent will be obtained (or explain how the study meets waiver guidelines for informed consent), how the data will be acquired, and how the data will be maintained once it is collected. Please attach pertinent supporting documents: all questionnaires, survey instruments, interview questions and/or data collection instruments, consent forms, and any research proposal submitted for funding.
6. **Will subject's data be gathered anonymously?** Do not confuse anonymous with confidential. For a study to be anonymous, there must be no possibility for the PI or anyone else to ascertain the identity of the subject(s).
7. **Type of subjects to be employed and recruitment procedures.** Please describe the subjects you intend to recruit. For example, minors under age 18, adults 18 and over, students, etc. Also, please describe your recruitment procedures. How will you find participants for your study? How will you contact them? Please be explicit.

Submit the original Research Exemption Request plus supporting documents via email and hard copy. It is recommended that the researchers keep a copy of their request for themselves.

IRB Approval 829.031710

Dear Sandra,

We are pleased to inform you that your above study has been approved by the Liberty IRB. This approval is extended to you for one year. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. Attached you'll find the forms for those cases.

Thank you for your cooperation with the IRB and we wish you well with your research project. We will be glad to send you a written memo from the Liberty IRB, as needed, upon request.

Sincerely,

Fernando Garzon, Psy.D.
IRB Chair, Liberty University
Center for Counseling and Family Studies Liberty University
1971 University Boulevard
Lynchburg, VA 24502-2269
(434) 592-4054
Fax: (434) 522-0477