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High School Engineering/Technology Education Course Impact on Georgia Standardized Achievement Scores

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HIGH SCHOOL ENGINEERING/TECHNOLOGY EDUCATION COURSE IMPACT ON GEORGIA STANDARDIZED ACHIEVEMENT SCORES

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ABSTRACT

HIGH SCHOOL ENGINEERING/TECHNOLOGY EDUCATION COURSE IMPACT ON GEORGIA STANDARDIZED ACHIEVEMENT SCORES

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This research explores whether a student completing a two course sequence in engineering/technology education is more successful on the Georgia High School Graduation Test (GHSGT) assessments in mathematics, science, social studies, and English/language arts. The findings provide additional insight into whether the current focus on STEM subjects (science, technology, engineering, and mathematics) could also improve student achievement in core academic areas. Student data were provided through the Georgia Department of Education database, from all public high schools in Georgia where engineering/technology education courses are taught. The school sizes ranged from the largest schools in the state (student population greater than 3000) to schools with less than 300 students in grades 9-12. The studied populations consisted of those students who had completed two courses in engineering/technology education, and those students who had taken no career, technical, agricultural education (CTAE) courses during their high school years before taking the GHSGT.

A quasi-experimental, post-test only design method was selected as the optimum approach for data analysis, as the two populations could not be randomly assigned and only the pre-existing results of the Georgia High School Graduation Tests (GHSGT) were utilized for data. The GHSGT data for all 2012 graduating classes in the four testing areas, English, mathematics, science, and social studies, were the dependent variables while participation or non-participation in engineering/technology education classes were the independent variables.

Multiple paired *t*-tests demonstrated a significant difference between students completing a two-course sequence in engineering/technology education and GHSGT scores in English, science, and social studies. Although a difference was indicated in mathematics, it was not statistically significant.

DEDICATION

This dissertation is dedicated to my loving wife and friend, Elaine. It was through her encouragement and confidence in me that this work was completed in a far quicker time and with less grief than had I done it without her. Additionally, to Kelci, our daughter, it is my hope you will continue to follow the path that enlightens you so that you can share your gifts with others. Your enthusiasm for learning provided me the impetus to continue when the tasks seemed insurmountable. You both make me a much better person. Thank you for being there.

Rodney Ragsdale

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This project would not be possible without a number of people, particularly Dr. John Ritz, my committee chair and a true Virginia gentleman, who worked tirelessly with me to improve my understanding of the history of my discipline and help me shape my information into useable data and effective writing. He was joined by my stalwart committee members, Dr. Dan Dickerson and Dr. Petros Katsioloudis. They encouraged me and guided me as only true professionals can. Gentlemen, your help and guidance was tremendous and greatly appreciated.

This more-years-than-I-expected research project gave me the opportunity to associate with a tremendous number of outstanding professional educators who were traveling this same dissertation path or who have taken the path before me. Each of them provided a unique and valuable contribution to my understanding of the profession of educators and each made me a better teacher.

Finally, I must acknowledge my industrial arts teacher, Mr. Billy Kimbrel. His totally out of the blue comment 40-plus years ago, that I should be an industrial arts teacher seemed so wrong and insignificant then but so astute and insightful today. Hopefully, he is not spinning in his grave, if he hears this thankful thought.

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INTRODUCTION

"The [n]ation that dramatically and boldly led the world into the age of technology is failing to provide its own children with the intellectual tools needed for the 21st century" declared findings of the National Science Board (National Science Board Commission on Precollege Education in Mathematics, 1983, p. v). This strong statement helped lead to the establishment of today's engineering/technology education curriculum as a means to provide context to the mathematics, science, social studies, and English subjects and provided a strong support to the concept of using engineering/technology education to help American students understand mathematics and science concepts (National Science Board Task Committee on Undergraduate Science and Engineering Education, 1986). Engineering/technology education, as it superseded industrial arts, became a multi-faceted subject that provides students a means of placing academic subject matter in a application context through the use of hands-on, problem-based learning.

The state of Georgia describes engineering/technology education as "the application of math and science for a specific purpose..." (Georgia Department of Education [GaDOE], 2005, p. 2). Georgia organizes engineering/technology education courses and other career, technical, and agricultural education (CTAE) courses into "career pathways", where they are considered elective courses. The goal of pathways is for students to complete three sequential courses in a specific field as a means for them to discover the connection between the world of work and other academic subject matter.

Georgia expects students to gain new skills and insights and to see the connection between their class work and career goals (GaDOE, 2009a).

The Georgia High School Graduation Test (GHSGT) was developed to measure whether Georgia secondary school students have mastered the essential content from the state curriculum (GaDOE, 2011a, para. 3). There are four separate tests that students earning a regular Georgia diploma must pass to earn a high school diploma. Those four test areas are mathematics, science, history/social studies, and English/language arts. Additionally students must also pass the Georgia High School Writing Assessment in order to graduate. Students and parents find these tests create great stress on students, because they must retake the tests and attain the required minimum scores in order to graduate high school (Newton & Walker, 1998).

Statement of the Problem

The problem of this study was to determine if successful completion of at least two engineering/technology education courses is positively related to students' high school achievement on state mandated standardized tests.

Hypotheses

The hypotheses that guided this study include:

H_{01}: There is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in English/language arts.

H_{02}: There is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in mathematics.

H_{03}: There is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in science.

H_{04}: There is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in social studies.

Background and Significance

The issue of determining whether career, technical, and agricultural education (CTAE) courses, and specifically engineering/technology education courses, influenced students' standardized assessment scores arose because of the growing emphasis on students passing these academic tests. Students were expected to succeed beyond minimal competency (Lee & Wong, 2004). States and local school systems found themselves forced to institute high-stakes testing to demonstrate students were being held to higher educational standards (Newton & Walker, 1998).

Frazier (2009) demonstrated a connection between students who were program completers at a Virginia high school with higher achievement on many portions of Virginia Standards of Learning (SOL) academic standardized assessments. This confirmation of the linkage between being successful technology education students and succeeding on standardized academic assessments brought a validation of Collicott and Skinner's (1934) view that Industrial Arts (the predecessor to today's engineering/technology education) intent was to provide "enriched conception where more of the child's interests and environment, and … other school subjects, are involved" (p. 1)

Frazier's research of 100 graduates from the 2008 class of an urban Virginia high school showed that the mean score on the state's mathematics standardized test for technology education completers was 466.9, while non-completers scored 441.7, with a valid level of significance. Additionally, his results for social studies demonstrated a similar finding; completers had a mean score of 502.0, while non-completers had a score of 463.8, again with an appropriate level of significance. His findings also supported an improvement on science standardized assessments when completers had a mean score of 459.7 against a non-completer mean score of 430.8. His findings did not support his hypothesis regarding an improvement in English/language arts scores as the completers' mean score was 474.7 against the non-completers' mean of 464.6; the significance finding was insufficient to support a positive correlation. If additional research, with a larger population and a different collection of valid and reliable assessment instruments produced similarly significant results, it could improve the status of engineering/technology education as a valid tool for teaching those critical courses and perhaps help make engineering/technology education a core curriculum requirement for all students.

Limitations

The limitations of this study were as follows:

1. The data were derived from high school students who completed at least two engineering/technology education courses and from students who took no engineering/technology education courses from high schools in Georgia where engineering/technology education courses are offered (GaDOE, 2008a).

2. The Georgia High School Graduation Tests (GHSGT) for mathematics, science, social studies, and English/language arts provided the standardized tests scores.

3. The data collection excluded the use of students who were members of the high school band at their respective high schools. This limitation was cited because research has shown that band students usually outperform other school populations when tested. According to Babo (2004), results from a study of middle school band students suggested that instrumental music participation does have a positive relationship to student achievement.

Assumptions

This study was based on the following assumptions:

1. Program completers have passed two sequential engineering/technology education courses.

2. All of the students were receiving a regular high school graduation diploma.

3. All students were taking the GHSGT without accommodations.

4. The schools involved in this study were accredited in the State of Georgia.

5. The engineering/technology education courses were taught by licensed teachers who followed the Georgia curriculum for these courses.

Procedures

In order to establish a comparison of engineering/technology education program completers to non-completers, it was necessary to obtain a list of random graduating seniors that had taken at least two sequential engineering/technology education courses. Those students were compared to a random sample of students who had not taken CTAE courses. The assessment scores for each student were obtained from the Georgia Department of Education. *t*-tests were used to determine if there were significant differences in GHSGT scores between the engineering/technology education program completers and non-program completers. The content areas analyzed for significance were English/language arts, mathematics, science, and social studies.

Definitions of Terms

The following definitions were provided to assist the reader in understanding the terms related to this study:

Career, technical, and agricultural education (CTAE): The term used by the state of Georgia to describe the following curricula: agriculture; architecture, construction, communications and transportation; business and computer science; culinary arts; education; engineering/technology education; family and consumer sciences; government and public safety; healthcare science; and marketing, sales and service (GaDOE, 2008a). It is often referred to as "CTE", career and technical education, in other states.

Engineering/technology education program completers: For the purpose of this research project, a completer is a student who successfully completes two sequential courses in the engineering/technology education curriculum.

Georgia High School Graduation Test (GHSGT): A set of four state standardized assessments that evaluate a student's academic performance in the subject areas of mathematics, science, history/social studies, and English/language arts.

Grade Point Average (GPA): The average of a student's grades they have received from each academic class they completed in high school.

Summary

This study investigates whether there is a significant difference between students taking a two course sequence in engineering/technology education and scores on the Georgia High School Graduation Tests (GHSGT) in four subject areas. Previous studies have shown mixed results between student scores on statewide tests and their participation in career, technical, and agricultural education (CTAE) courses. This study utilizes the entire 2012 graduation cohort of Georgia public high school students who took the 2011 administration of the GHSGT and compares the scores in the mathematics, English/language arts, science, and social studies portions between those students who had not taken any CTAE courses and those who had taken at least two CTAE engineering/technology education courses.

Further details regarding the foundations of engineering/technology education, the drive to provide standardized assessments of student performance on academic courses, the demand for accountability for Perkins funding, and the relationship between CTAE courses and student achievement will be provided in Chapter II, Review of the Literature. The methods used to collect and analyze data will be provided in Chapter III, Methods and Procedures. The results of the data analysis will be detailed in Chapter IV, Findings. The summary, conclusions, and recommendations of this study will be drawn in Chapter V.

CHAPTER II

REVIEW OF THE LITERATURE

Engineering/technology education has a diverse history that has evolved as the world has grown more and more technically complex. This chapter will explore the major topics that have shaped the field and that are continually changing it. The topics that will be explored include the background and philosophy of the field, the standards assessment movement and its impacts, a comparison between the content of academic courses and engineering/technology education courses, and the methods that engineering/technology education are using to enhance student achievement.

Philosophical Underpinnings

Both the constructivism of Piaget and the progressivism of Dewey underlie the curriculum of career, technical, and agricultural education (CTAE) programs, and especially engineering/technology education courses. Dewey (1916) advocated that students must have a genuine experience that stimulates thought which connects to prior knowledge. Piaget's work called for critical thinking and problem solving as effective means to improve student learning (Berns & Erickson, 2001). This improvement in student knowledge and retention via hands-on methods in the engineering/technology education classroom validates its transfer of understanding to academic coursework (International Technology and Engineering Educators Association [ITEA], 2007).

Critical thinking requires a student to recognize central issues and important relationships, deduce solutions from data, and evaluate whether solutions are appropriate based on available data (Rudd, 2007). Facione (1990) identified three key dispositions of critical thinkers: engagement, cognitive maturity, and innovativeness. Students with a high degree of engagement enjoy problem solving and are able to explain their thought processes to others, while having cognitive maturity permits students to listen to others with an open mind, and innovative students look for new knowledge and ask questions of others to learn (Rudd, 2007). Students who use critical thinking techniques to solve problems scored higher on content-based assessments than students who were taught through traditional lecture and textbook methods (Nokes, Dole, & Hatcher, 2007). Problem-based learning classrooms hone these skills and permit students to "carry on systematic and protracted inquiry" (Dewey, 1938, p. 13) as they draw upon their prior academic and technical knowledge to solve problems. Problem-based learning activities enabled students to demonstrate self-direction, teamwork, creative discussion, and integration and synthesis of knowledge (Gurses, Acikyildiz, Dogar, & Sozbilir, 2007).

Students in engineering/technology education classrooms follow *Standards for Technological Literacy* (ITEA, 2007) which recommends using problem-solving skills to work on assorted real-world situations. The standards also call for the integration and application of a student's course material into the engineering/technology education classroom to permit the student to see the interconnection between academic knowledge and the real world.

What Is Engineering/Technology Education

The engineering/technology education curriculum traces its lineage to the Russian manual training movement in the mid-1800s. Victor Della Voss created the system to help train Russian engineers; Calvin Woodward modified the system to establish the St. Louis Manual Training School as a means to benefit students through the development of skills in the use of people, places, and things (Woodward, 1887). The industrial arts movement, begun in the 1920s to provide a method of connecting the academic world to the world of work for students, marked the beginning of the transition from a strictly vocational focus of training to a more general focus on learning for students (Foster, 1997). This connection of the kinesthetic to the academic was highlighted by Donald Maley, author of the *Maryland Plan*. His plan stressed the function and role of industrial arts education in a technologically dominated democracy, the relationship between the school, its students, and the community, the working conditions of the present and the future, and the impact of change on a society (Maley, 1969). The *Jackson Mill Industrial Arts Curriculum Theory* (1981), assembled by a team of industrial arts educators, redirected the aim of industrial arts education from its industrial arts/industry base towards a general education subject that grouped the technologies studied into the technologies defined by industry, encouraged students to see the impacts of technology on society and vice versa, and taught students to study the past and the present to forecast the future of the technological world (Lewis & Zuga, 2005).

The Carl D. Perkins Vocational Education Act of 1984 created the present framework of career and technical education with its directive that states should expand, modernize, and develop vocational education programs that meet the needs of the nation's future workforce (Department of Education [DoE], 1986). This funding vehicle forced state departments of education to re-vamp their existing industrial arts shops into more technically advanced laboratories that began to mirror the technological changes that were sweeping the nation's businesses and industries. The change in focus by the federal government gave impetus to the American Industrial Arts Association (AIAA) to change its name to the International Technology Education Association (ITEA) in 1986.

These changes continued with the current re-authorization of the Carl D. Perkins Career and Technical Education Improvement Act of 2006 (Perkins IV). This law required that "academic attainment will now have to be measured by the academic assessments a state has approved under NCLB. Graduation rates also must be reported as defined in NCLB…" (Florida Department of Education, 2008).

The Perkins Act authorization expired at the end of FY12 and the continuing disagreements between the national political parties has placed its reauthorization on hold, although the Act has continued to be funded annually (Association for Career & Technical Education, 2014). The act was unanimously approved by the Senate and a 399-1 favorable vote in the House of Representatives in 2006 (National Skills Coalition, 2011) indicates the likelihood of its survival. Whether it is reauthorized or not, the Obama Administration, through its "Race to the Top" program focused school improvement goals at increasing the number of students who pursue STEM (science, technology, engineering, and mathematics) careers, increasing the number of students who successfully complete a 4-year college degree, and implementing more rigorous standards and assessments to support the needs of students for both college and careers (Montalo, 2013).

The state of Georgia organizes engineering/technology education courses and other career, technical, and agricultural education (CTAE) courses into *Career Pathways*, where they are considered elective courses. The goal of pathways is for students to complete three sequential courses in a specific field as a means for them to discover the connection between the world of work and the academic subject matter. The state expects students to gain new skills and insights and to see the connections between their class work and career goals (Georgia Department of Education [GaDOE], 2009a). This change occurred due to a growing demand for an engineering design focus in the technology education curriculum from both teachers and industry leaders. Teachers stated a desire for integrating mathematics and science into the curriculum, a belief that the implementation of engineering design (and the associated name change) elevated the program and the teacher's status, and a belief that the name change would better explain what the curriculum included (Denson, Kelley, & Wicklein, 2009).

The Route to Career Pathways

The National Association of State Directors of Career Technical Education Consortium (NASDCTEc) designated 16 career clusters to help state education agencies develop curricular frameworks that would prepare students for a successful transition from high school to either employment in a career area or postsecondary education and a follow-on career. The objective for Career Clusters is to provide a means for students to become aware of the career options provided by their educational choices, to improve student achievement by teaching academics in context to the world of work. Georgia expanded the NASDCTEc list to 17 Career Clusters after input from Georgia Power, one of its major businesses, with the addition of the Energy Career Cluster. The number of Georgia high school educational pathways supporting each Career Cluster varies from 20 agriculturally related pathways to two supporting Energy, see Figure 1.

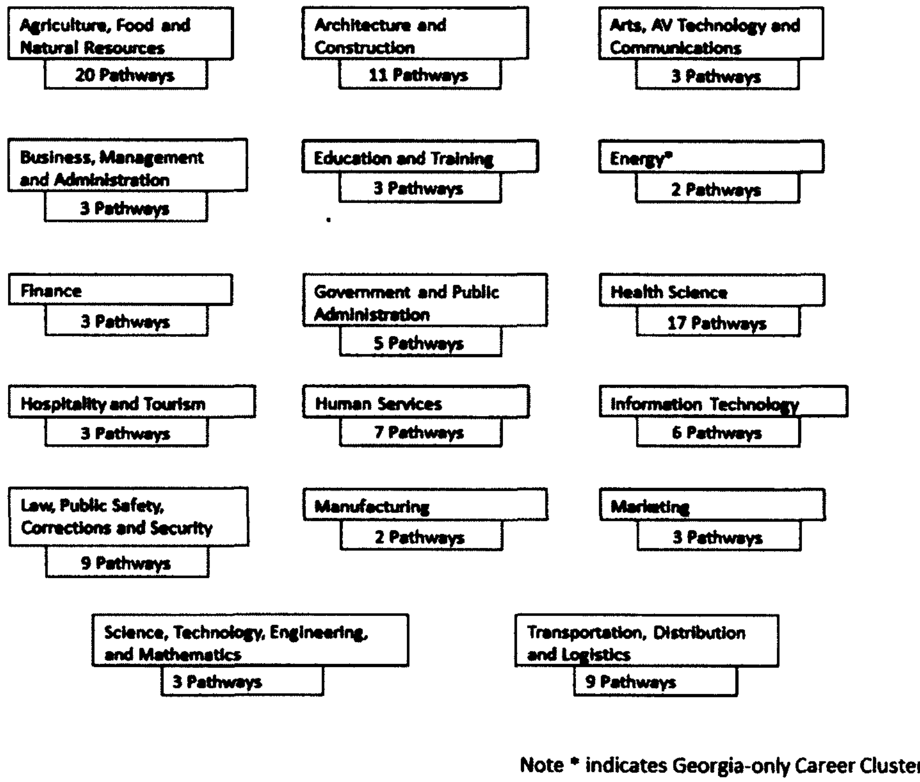

Figure 1. Georgia's Career Clusters and Their Number of Career Pathways (GaDOE. 2014b).

The Georgia Engineering/Technology Education Career Pathway

Although engineering and technology concepts can be found in each of the 17 clusters, the Science, Technology, Engineering, and Mathematics Career Cluster is the designated pathway for the Georgia engineering/technology education curriculum. The state began to replace its technology education offerings in 2007. Georgia's engineering/technology education *career pathway* consists of seven distinct curriculum areas: electronics; energy and power: generation, transmission, and distribution; energy systems; engineering; engineering, drafting and design; manufacturing; and manufacturing-mechatronics. Students are required to complete the three required courses of a curriculum area in sequence (Figure 2) and pass an end of pathway assessment to be awarded a pathway completion certificate (GaDOE, 2010). The engineering/technology education pathway averaged an enrollment of 42,000 students a year during this research study's cohort, roughly 14% of the students enrolled in the state's CTAE programs over the same period (GaDOE, 2008b; GaDOE, 2009c; GaDOE, 2010; GaDOE, 2011b).

Electronics

21.45200 Foundations of Electronics*
21.45300 Advanced AC and DC Circuits*
21.45400 Digital Electronics*
21.47800 Electronics Internship

Energy Systems

49.53700 Foundations of Energy Technologies* (*replacing the Foundations of Engineering and Technology in August 2014*)
21.45100 Energy and Power Technology*
21.45700 Appropriate and Alternative Energy Technologies*
21.44800 Energy Systems Internship

Engineering, Drafting and Design

48.54100 Introduction to Drafting and Design*
48.54200 Survey of Engineering Graphics*
48.54300 3D Modeling and Analysis*

Manufacturing-mechatronics

21.46200 Introduction to Mechatronics - DC Theory, Pneumatic Systems, and Programmable Logic Controllers*
21.46300 AC Theory, Electric Motors, and Hydraulic Systems*
21.46400 Semiconductors, Mechanical Systems, and Pump and Piping Systems*

Energy and Power: generation, transmission, and distribution

49.53700 Foundations of Energy Technologies*
49.53800 Energy & Power: Generation, Transmission, & Distribution*
49.53900 Energy Systems Applications*

Engineering

21.42500 Foundations of Engineering and Technology*
21.47100 Engineering Concepts*
21.47200 Engineering Applications*
21.46800 Engineering Internship

Manufacturing

21.44100 Foundations of Manufacturing and Materials Science*
21.44500 Robotics and Automated Systems*
21.44400 Production Enterprises*
21.45800 Manufacturing Internship

*= required for pathway

Note: 21.XXXXX is engineering/technology education curriculum
48.XXXXX is precision manufacturing curriculum
49.XXXXX is manufacturing curriculum

Figure 2. Engineering/Technology Education Pathway Courses (GaDOE, 2014a).

The Standards Movement

Horace Mann, in 1845, helped organize one of the first attempts to assess academic achievement between different schools, when he and members of the Boston school establishment used timed, written tests. Yet, due to the Constitution leaving education to the individual states, the United States never evolved a centralized agency that could mandate uniform assessments to the thousands of locally-controlled education agencies (Reese, 2007). The 1983 publication of *A Nation at Risk* by the National Commission on Excellence in Education shocked the country with its findings that 40 percent of 17-year-olds could not draw inferences from what they had read, 80 percent could not write a persuasive essay, and 66 percent could not solve a multi-step mathematics problem. The Clinton Administration passed, in 1994, *Goals 2000: Educate America Act*, which called for school systems to have content and performance standards and assessments connected to those standards. When President George W. Bush signed into law in 2002, the No Child Left Behind Act, the nation had seen 48 states implement their own visions for assessing student performance as encouraged by *Goals 2000* (Jorgensen & Hoffman, 2003). The NCLB Act required each state to test their students at least once during their high school years on reading, mathematics, and science. This requirement to test students within each state on the same exam increased the status of those courses, implicitly required teachers to modify their curriculum and teaching methods to ensure their students "pass" the tests, and gave parents, politicians, and business leaders a method of evaluating just how "effectively" a school taught students (Reese, 2007).

Variable Impacts on Standardized Tests

The use of standardized assessments provides educators and policy makers an ability to discern both in-school and out of school factors that influence student success on the measured subjects. Demographics, teaching styles, curriculum, and nearly all other variables can be tracked to determine whether the variable impacts student achievement.

A study by two University of British Columbia researchers, Zumbo and Gelin (2005), identified four socio-economic groupings that influence student performance on standardized mathematics assessments: rural low-income, rural affluent, urban low-income, and urban affluent. Their study of 120,000 British Columbia students revealed that although gender moderated some of the effects of these four groupings, student achievement was impacted by both the student's geographic location and the student's economic status. This study seems to support the findings of Koretz and Kim (2007) that there is not a widening gap in mathematics knowledge and skills assessments between White and Black students. This study found no support for an increasing gap in achievement as students aged, although the authors did argue the gap can vary across subpopulations and that different results might occur with different tests, leaving the argument that race might influence student achievement on standardized tests.

Green (2008) attempted to discern whether demographics among CTAE students influenced their standardized tests scores. His study revealed that race had no effect on female CTAE students' scores, while Black males' scores were negatively impacted by race. Additionally, male scores, in general, were negatively impacted by low socio-economic status, while females seemed unaffected. Bock (2008) also confirmed a negative impact of low socio-economic status on standardized scores among Mississippi CTAE (career, technical, and agricultural education) students. The study showed that for every one percent increase in free and reduced lunch participation, standardized test scores dropped .14%. Additional influences uncovered by Bock showed that student standardized scores rose the longer a CTAE teacher had taught, if the teacher were National Board Certified, and if the teacher had a bachelor degree or higher.

Comparison of Academic Course Content and Engineering/Technology Education Content

Georgia identifies the major concepts in each curriculum subject area as Georgia Performance Standards (GPS). The Georgia High School Graduation Test (GHSGT) requirements for each academic area are cross-walked via the GPS to enable both student and teacher to understand what content areas are assessed on the test. The Engineering/Technology Education instructional units contain both the GPS for the course itself, but also the GPS for the mathematics, science, social studies, and/or English/language arts content that should be taught in each unit of instruction. Although not every GPS is addressed in every unit of an Engineering/Technology Education lesson, at least three or four mathematics and science GPS are addressed in most units, with social studies and English/language arts addressed in many units. Table 1 shows the crosswalk of the GPS in the introductory Foundations of Engineering course for one unit taught in the middle of the course.

Although the introductory course is primarily taught to freshmen and sophomores, some of the GPS standards in the course are taken from academic classes that students take in their sophomore or junior years. An example is the mathematics GPS standard MM3P4 which is found in Georgia's Mathematics 3 course. This standard requires students to make connections between mathematical ideas and other disciplines, to understand the connection between different mathematical concepts, to see how mathematical ideas interconnect to create a coherent whole, and to apply those ideas in contexts outside mathematics. Students in the Foundations of Engineering course are therefore exposed to problems that require them to utilize their mathematical knowledge, correlate it to the assigned problem, and create solutions using that interconnectedness in order to successfully pass the unit listed in Table 1 (GaDOE, 2009b). This interconnection of prior mathematics knowledge, coupled with an assigned engineering/technology education problem to successfully pass a unit in the course demonstrates the adherence of Georgia's engineering/technology education program to the Standards of Technological Literacy advocated by the International Technology and Engineering Educators Association [ITEEA] (ITEA, 2007).

Table 1

GPS Crosswalk within Engineering/Technology Education.

Georgia Foundations of Engineering GPS standards for Unit 9 Manufacturing Systems

Unit	GPS	Description
Social Studies	SSUSH11	... describe the economic, social, and geographic impact of the growth of big business and technological innovations after Reconstruction.
	SSUSH21	...describe the economic, social, and geographic impact of the growth of big business and technological innovations from 1945-1975.
	SSUSH24	... analyze the impact of social change movements and organizations of the 1960s.
	SSWH21	...analyze globalization in the contemporary world.
Science	SCSh3	...identify and investigate problems scientifically
	SCSh4	...use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.
	SCSh5	...demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.
	SCSh6	... communicate scientific investigations and information clearly.
	SCSh7	... analyze how scientific knowledge is developed.

Table 1 Continued

Unit	GPS	Description
Science	SCSh8	… understand important features of the process of scientific inquiry.
Mathematics	MM3P1	… solve problems (using appropriate technology).
	MM3P2	… reason and evaluate mathematical arguments.
	MM3P4	… make connections among mathematical ideas and to other disciplines.
	MM3P5	… represent mathematics in multiple ways.
English/ Language Arts	ELAALRC2	. … participates in discussions related to curricular learning in all subject areas.
	ELAALRC3	… acquires new vocabulary in each content area and uses it correctly.
	ELAALRC4	… establishes a context for information acquired by reading across subject areas

Note:

SSUSH	Social Studies, US history
SSWH	Social Studies, World history
SCSh	Science, Characteristics of science
MM3P	Mathematics III, Process standards
ELAALRC	English/Language Arts, American literature, reading comprehension

Source: (GaDOE, 2009a; GaDOE, 2011a).

Relationship Between CTAE and Student Achievement

Georgia utilizes two different sets of standardized tests to meet the demands of NCLB (No Child Left Behind): (a) the Georgia High School Graduation Tests (GHSGT) in mathematics, science, history, and English (The Governor's Office of Student Achievement, 2008) and (b) End of Course Tests (EOCTs) in specific courses of mathematics, science, history, and English (GaDOE, 2005b). These metrics are vital to measure the success of the efforts needed to raise the graduation rate of Georgia students from 61.2 percent in 2004 to the NCLB mandated 100 percent in 2014 (Snyder & Dillow, 2006). All students who graduated at the end of the 2012 school term took the GHSGT in all areas. Students graduating in 2013 and beyond must either pass an EOCT or the GHSGT in the subject in which they did not pass the EOCT (GaDOE, 2012).

Even before NCLB impacted the education community, the impact of CTAE courses on student achievement was being noted by Plank (2001) as he mined the data found in the National Educational Longitudinal Study of 1988. Plank highlighted data that showed students who completed a dual-curriculum of academic and CTAE courses and students who pursued a purely academic high school curriculum had nearly identical scores on standardized tests in mathematics, science, history, and English. His study also noted a correlation between students who took a moderate amount of CTAE courses and a higher graduation rate. The Plank study was replicated by Curtis in a rural Georgia school district and the same standardized test score relationships between students pursuing a dual-curriculum and purely academic courses were again found. However, Curtis (2009) noted an inability to determine a relationship between high school graduation rates and whether a student followed a dual-curriculum or purely academic studies.

The impact of career, technical, and agricultural education programs on student standardized test scores has an inconclusive research history. In a comparison between three Colorado high schools' CTE (career and technical education) programs and college-preparatory programs, ACT scores demonstrated a positive relationship in ACT and GPA scores between students who took technology education courses (robotics, architectural design, and manufacturing) and those college-preparatory students who took courses in physics, AP chemistry, and AP language arts. Most other CTE programs failed to demonstrate a link to higher ACT scores (Haniford, 2008). Meanwhile, a Louisiana State University study of the influence an agri-science curriculum had on the Louisiana Graduate Exit Exams (GEE) failed to find any significant change in standardized scores in science, mathematics, social science, and English (Theriot, 2007).

The Plank (2001), Haniford (2008), and Curtis (2009) studies looked at the impact of all CTAE programs on overall student achievement and detected a positive relationship between CTAE and student achievement. Yet Theriot (2007) did not detect an improvement in student standardized test scores if they had participated in Louisiana's agri-science classes. Frazier (2009) gives more focus to the advantages of a student enrolling in Virginia's technology education courses with his findings that students completing two associated technology education course (e.g., graphics communications and communications systems) scored better on Virginia's Standards of Learning (SOL) standardized tests in mathematics, science, history, and English. His research showed technology education program completers scored better on the mathematics, science, and history SOLs than non-completers, but the data failed to show a significant difference between program completion and higher scores for the English SOL.

Why More Research

As budget reductions impact school funding, teachers of elective courses (to include CTAE) are often among the first to be cut, since their subjects are not part of most states' graduation requirements. Additionally, students in high school, unlike college students, must take a required number of courses each term and may not take extra courses, thus students must make difficult scheduling choices with little valid data to determine whether to take an engineering/technology education course or another elective. If data were available to show the value of engineering/technology education courses in improving student achievement on standardized assessments necessary to graduate, then the likelihood the student would opt for engineering/technology education course would increase. Although Frazier's (2009) study provides support for encouraging Virginia students to complete a technology education curriculum due to the relationship between SOL scores and those students who did take the Virginia technology education curriculum, and Theroit's (2007) study demonstrated a connection between student achievement and those students who took agri-science courses in Louisiana; neither of the studies can be easily applied to Georgia due to the differences in the curriculum in Georgia, Virginia, and Louisiana. Due to the variation in the curricula and the differences in standardized tests, one cannot easily apply the findings of Frazier or Theriot to Georgia, thus the value of the engineering/technology education curriculum as a means to improve student achievement and help increase the graduation rate of Georgia students cannot be adequately argued.

Summary

Chapter II covered topics detailing the history of engineering/technology education. Significant legislation leading to the development of technology education and standardized assessments were discussed. This chapter also expressed the impact of No Child Left Behind and high stakes testing on teachers and students. The final portion of this chapter presented data that were supportive of the notion that technology education can contribute to the increase in student's performance in other subject areas. The basis of this study is to see if the teaching of technology education led to improved learning in science, social studies, mathematics, and English/language arts. Chapter III will provide a profile of the population of students that were used in this study and the procedures of gathering research data.

CHAPTER III

METHODS AND PROCEDURES

The methods and procedures used in this study are described in this chapter. It will discuss the population chosen for this study, research variables, instrument design, the methods of data collection, and the statistical analysis. This study is quasi-experimental in nature.

Population

The population of this study of Georgia public high school students (N = 87,591) consisted of a random sample of 661 engineering/technology education program participants and an equal random sample number of non-participants from all Georgia public high schools who offered an engineering/technology education program for at least two years prior to the Spring 2011 administration of the Georgia High School Graduation Tests. The population was composed of 11th grade students during the 2010-11 school year, as these students all had to complete each area of the GHSGT in order to graduate; subsequent classes can meet graduation requirements by successfully completing an end-of-course test (EOCT) in these subjects. The sample of engineering/technology education program participants was a random selection of those students who had completed two courses or were in the second of two courses in the engineering/technology education program before taking the Georgia High School Graduation Tests in the last semester of their junior year (March, 2011). The students were classified as program participants instead of pathway completers because Georgia requires students to complete three courses sequentially to be designated a pathway completer and most students are unable to take the third course before taking the GHSGT due to scheduling conflicts with other required courses.

The control group consisted of those students who had taken no career, technical, and agricultural education (CTAE) courses in high school before taking the Georgia High School Graduation Tests in spring of their junior year. This sample of students was randomly selected from each high school's graduating class. Each participant school employed at least one licensed engineering/technology educator.

Georgia requires all graduating high school students to have successfully completed four courses in English/language arts, mathematics, and science; three courses in social studies; and one course of health/physical fitness ("required courses"). Students must also complete three courses in either foreign languages, fine arts, or CTAE (career, technical, and agricultural education) coursework and four electives of any type course (GaDOE, 2009b). Table 2 lists these requirements.

Table 2

Georgia Graduation Rule

Course Requirements
23 total units required for all students
4 units of English Language Arts required
4 units of Mathematics required
4 units of Science required for all students (the 4th science unit may be used to meet both the science and elective requirements)
3 units of Social Studies required
1 unit of Health and Physical Education required for all students; 3 units of JROTC may be used to meet the requirement

Table 2 Continued

A total of 3 units required from: CTAE and/or Foreign Language and/or Fine Arts for all students *(students planning to enter or transfer into a University System of Georgia institution or other post-secondary institution must take two units of the same foreign language)*
4 additional elective units for all students

Source: (GaDOE, 2009b).

These requirements consume 23 class periods, while students have 24 class periods if they attend a school that operates a six period schedule, 28 class periods in those schools operating a seven period day, or 32 class periods in schools operating a 4x4 block schedule. This constraint of time is confounded by student desires to participate in extra-curricular activities such as sports or band which carry implicit demands for additional classes of PE or band/chorus. Additionally, nearly all students are actively encouraged to take foreign language courses, typically beginning the sophomore year. These additional demands on a student's schedule tend to impact when a student's schedule has space for any CTAE courses. This constraint in scheduling reduces the number of students available for selection as many students do not get into their engineering/technology education courses until the beginning of their junior year and some do not take their second course until the start of their senior year.

Research Variables

The independent variables for this study were students, with two levels: engineering/technology education pathway participants and CTAE (career, technical, and agricultural education) pathway non-participants. Neither population included students who had taken any band or chorus class during their high school years before taking the Georgia High School Graduation Tests (GHSGT). The dependent variables were the student scores on the GHSGT in the areas of English/language arts, mathematics, science, social studies. Students are required to complete the GHSGT during spring of their junior year.

Instrumentation Design

In order to analyze the performance of the engineering/technology education program participants on the GHSGT, as opposed to the performance of students who did not take an engineering/technology education course, the researcher compared the GHSGT scores in the four categories. The GHSGT exams were created as an assessment instrument for all Georgia public high school juniors. The first students completed all areas of the test in 1996 (GaDOE, 2004). The English/language arts, mathematics, science, and social studies GHSGT are all multiple-choice in testing form. The English/language arts portion of the exam has 65 items, science has 80 items, social studies contains 90 items, and mathematics has 65 items. Students have up to three hours to complete each section of the test.

The scaled scores for the exams are 100-350 for English/language arts, 100-400 for mathematics, 100-450 for social studies, and 100-370 for science (GaDOE, 2011a). Two reliability indices are used for the GHSGT program. The first index is Cronbach's alpha reliability coefficient, which shows the consistency of test scores as the ratio of true score variance to observed total score variance (i.e., true score variance plus error variance). Georgia utilizes the standard error of measurement (SEM) as its second statistical index to describe test score reliability. The SEM is an index of the random variability in tests scores in raw score units.

Table 3 shows the reliability indices in terms of Cronbach's alpha for the Spring 2011 tests. The reliability coefficient ranges from 0 to 1 and is a unitless index, which can be compared from test to test. The table shows that the reliability indices for the GHSGT range from 0.89 (English/language arts) to 0.94 (social studies). The reliabilities and SEMs for the Spring 2011 GHSGT administrations indicate that the GHSGT assessments are sufficiently reliable for their intended purpose. The statistical significance (α) varies from α = 0.05 for social studies to α = 0.1 for the other tests.

Table 3

Reliability Indices for GHSGT

Spring 2011 Reliability Measures					
Subject	Administration	Number of items (* = α)	Mean	Standard Deviation	Raw score (standard error of measurement)
English/ Language Arts	Spring 2011	55*	41.13	8.61	2.91
Mathematics	Spring 2011	65*	37.25	9.68	3.09
Science	Spring 2011	70*	49.49	11.43	3.39
Social Studies	Spring 2011	80*	51.44	15.74	3.80

Source: (GaDOE, 2011a).

Methods of Data Collection

Pre-existing data were retrieved from the Georgia Department of Education databases of all 2012 public high school graduating students who took the GHSGT for the first time in Spring 2011 in the state of Georgia. Data were provided in a matrix as shown in the Appendix, only partial data is shown due to the size of the database. The researcher was provided access to the standardized assessment records anonymously for each student in the study's population. The data included the GHSGT scores in English/language arts, mathematics, science, and social studies. The provided student data included all student CTAE course numbers and band classes for those classes in which the student enrolled through the student's junior year of high school (when the student is given the Georgia High School Graduation Tests for the first time). If a student had not taken any CTAE or band courses, then that student was a potential member of the control population. If the student had taken two or more engineering/technology education courses and had not taken any band courses, then the student was a potential member of the studied population. Protection of human subjects was maintained by keeping the identity of each participant anonymous to the researcher; only the student identity number was provided to the researcher with no other identifying data. Data were collected, solely by school-assigned student numbers, then inputted into SPSS where each student was assigned a new identification number to eliminate any connection to the school identity. The researcher aggregated data from SPSS to report data. All data provided to the researcher were secured.

Statistical Analysis

Multiple paired *t*-tests were calculated for each hypothesis to determine if the scores were significantly different between the GHSGT scores of the engineering/technology education program completers as opposed to the scores of the non-program participants. The GHSGT scores of the non-participants were used to determine if there were a significant difference in the scores between the groups. The *t*-

test determines whether the means of the groups were statistically different and it is appropriate to determine whether the mean scores of the completers were statistically different than those of the non-participants.

Summary

Chapter III outlined the methods and procedures used to complete this study. The sequencing of courses within Georgia's engineering/technology education pathways provided a view into the focus of each pathway. The unit and subject requirements for a student to graduate from Georgia high schools and the impacts of scheduling that a student had to navigate in order to get those credits while following a chosen career, technical, and agricultural education (CTAE) pathway demonstrated the difficulty of many students completing two courses by the time of the administration of their Georgia High School Graduation Test (GHSGT). The reliability of the 2011 administration of the GHSGT, coupled with the use of the multiple paired *t*-tests established the validity of the test design. These data will be presented as findings in Chapter IV.

CHAPTER IV

FINDINGS

The problem of this study was to determine if successful completion of at least two engineering/technology education courses is positively related to students' high school achievement on state mandated standardized tests. This chapter contains data that were collected to satisfy the four aspects of this study. The data were used to determine if there were significant differences between state standardized student assessment scores in English/language arts, mathematics, science, and social studies with engineering/technology education course completers and students who did not take engineering/technology education courses during high school.

Program Completers

The program completers for this study were randomly selected from those students taking the necessary sequential engineering/technology education courses from engineering/technology education programs throughout the state of Georgia. The courses taken by the 2012 high school graduates were analyzed and the population of program completers was determined based on the sequence of their engineering/technology education courses. The number of engineering/technology education program completers randomly selected was 661. The population of non-completers was determined by randomly selecting students who had not taken any career, technical, and agricultural education (CTAE) courses before taking the Georgia High School Graduation Tests (GHSGT) in Spring 2011. This random sample selected for non-CTAE program completers was 661. The demographics of the students in this study were reflective in regards to Asian, Black, Hispanic, Mixed, and White students and male and female students as compared to the overall population of students in the Georgia Public School System. Population groups of other ethnicities/races were too small to permit disaggregation under the Family Educational Rights and Privacy Act of 1974. Table 4 shows a summary of the demographics, as denoted by the state, for the state public high schools during the testing period as gathered from the Georgia Department of Education database (GaDOE, 2013).

Table 4

Student Demographics for Sample Population and Georgia Public High School Students

Student Ethnicity/Gender/ Race	Students in Populations (661)		2011 GHSGT Georgia Public High School Students (87,591)	
	Number	Percentage	Number	Percentage
Asian Females	8	1.3	1120	1.3
Asian Males	10	1.4	1280	1.5
Black Females	138	20.2	18277	20.8
Black Males	120	18.2	15920	18.2
Hispanic Females	22	3.4	2971	3.4
Hispanic Males	21	3.3	2722	3.3
Mixed Females	3	0.5	376	0.4
Mixed Males	2	0.3	292	0.3
White Females	171	25.8	22621	25.8
White Males	166	25.1	22012	25.1

English

The first research hypothesis states that GHSGT English/language arts test scores of students who were engineering/technology education program completers would not show a difference in test scores with students who had not completed any engineering/technology education courses. The findings of this hypothesis show the mean score for program completers was higher on the GHSGT English/language arts (M = 244.74, SD = 29.22) than the mean score for students who had not taken engineering/technology education courses (M = 236.44, SD = 29.00); $t(1320) = 5.18$, $p < .001$. Table 5 lists the independent samples t-test of the engineering/technology education program completers and the non-completers.

Table 5

Group Statistics (English/Language Arts)

Tech Ed	N	Mean	Std. Deviation	Std. Error Mean
Yes	661	244.74	29.22	1.14
No	661	236.44	29.00	1.13

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Score	Equal variances assumed	.037	.847	5.18	1320	.000	8.30	1.60	5.16	11.44
	Equal variances not assumed			5.18	1319.92	.000	8.30	1.60	5.16	11.44

Mathematics

The second research hypothesis stated that Georgia High School Graduation Test mathematics test scores of students who are engineering/technology education program completers would not show a difference with students who had not completed any engineering/technology education courses. The findings of this hypothesis show the mean score for program completers was higher on the GHSGT mathematics test ($M = 248.00$, $SD = 46.46$) than the mean score for students who had not taken engineering/technology education courses ($M = 246.63$, $SD = 60.46$); $t(1320) = 0.46$, $p = 0.65$. Table 6 lists the independent samples *t*-test of the engineering/technology education program completers and the non-completers.

Table 6

Group Statistics (Mathematics)

Tech Ed	N	Mean	Std. Deviation	Std. Error Mean
Yes	661	248.00	46.46	1.81
No	661	246.63	60.46	2.35

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Score	Equal variances assumed	5.116	.024	.46	1320	.65	1.36	2.97	4.45	7.18
	Equal variances not assumed			.46	1237.99	.65	1.36	2.97	4.45	7.18

Science

The third research hypothesis stated that Georgia High School Graduation Test science test scores of students who are engineering/technology education program completers would not show a difference with students who had not completed any engineering/technology education courses. The findings of this hypothesis show the mean score for program completers was higher on the GHSGT science test ($M = 252.09$, $SD = 31.52$) than the mean score for students who had not taken engineering/technology education courses ($M = 241.71$, $SD = 31.57$); $t(1320) = 5.98$, $p < .001$. Table 7 lists the independent samples *t*-test of the engineering/technology education program completers and the non-completers.

Table 7

Group Statistics (Science)

Tech Ed	N	Mean	Std. Deviation	Std. Error Mean
Yes	661	252.09	31.52	1.23
No	661	241.71	31.57	1.23

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference: Lower	95% Confidence Interval of the Difference: Upper
Score	Equal variances assumed	.061	.805	5.98	1320	.00	10.38	1.74	6.98	13.79
	Equal variances not assumed			5.98	1320	.00	10.38	1.74	6.98	13.79

Social Studies

The final research hypothesis stated that GHSGT social science test scores of students who are engineering/technology education program completers would not show a difference with students who had not completed any engineering/technology education courses. The findings of this hypothesis show the mean score for program completers was higher on the GHSGT social studies test (*M* = 246.37, *SD* = 46.85) than the mean score for students who had not taken engineering/technology education courses (*M* = 238.04, *SD* = 45.02); $t(1320) = 3.30, p < .001$. Table 8 lists the independent samples *t*-test of the engineering/technology education program completers and the non-completers.

Table 8

Group Statistics (Social Studies)

Tech Ed	N	Mean	Std. Deviation	Std. Error Mean
Yes	661	246.37	46.85	1.82
No	661	238.04	45.02	1.75

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper
Score	Equal variances assumed	.580	.446	3.30	1320	.001	8.33	2.53	3.38	13.29
	Equal variances not assumed			3.30	1317.93	.001	8.33	2.53	3.38	13.29

Summary

Chapter IV reported the results of the data collected from the Georgia High School Graduation Tests (GHSGT) in the subject areas of English/language arts, mathematics, science, and social studies. The students who were technology education program completers were compared to students whom were not enrolled in technology education courses. Multiple independent sample *t*-tests were used to determine the level of significance between program completers and students who had not taken a course in engineering/technology education. Student test scores were higher in all four tested subject areas for those students who were engineering/technology education program completers, with statistically significant correlations in English/language arts, science, and social studies. The mathematics test score was not statistically significant (Figure 3). Chapter V will provide the Summary, Conclusions, and Recommendations of this study.

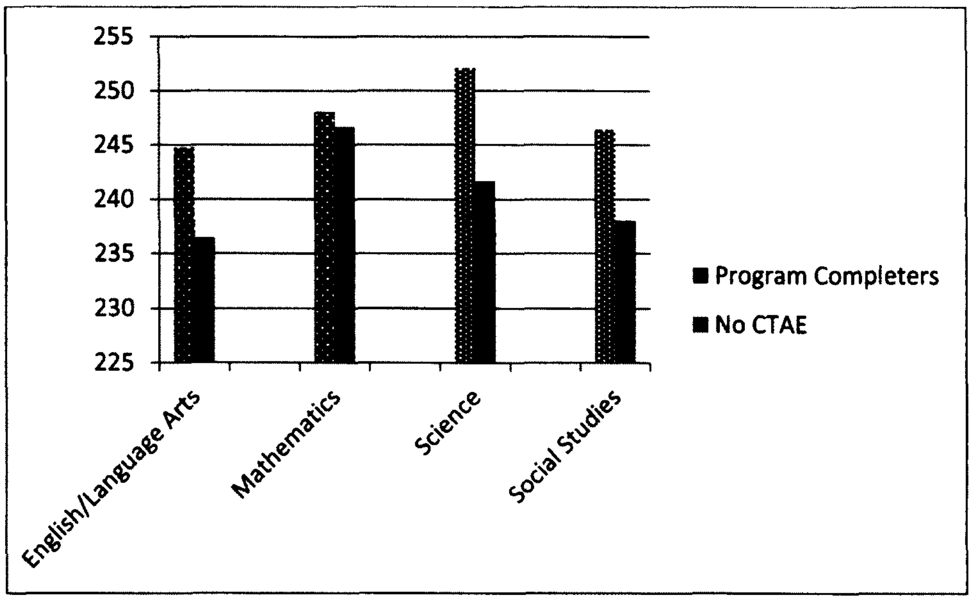

Figure 3. Mean Score Comparisons of Program Completers and No CTAE Students

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study sought to determine if students completing at least a two course sequence in engineering/technology education improved their scores on Georgia High School Graduation Tests in English/language arts, mathematics, science, and social studies. The information in this study was based on the results of data collected from the 2012 graduating class of Georgia public high schools. A random sample derived from those 87, 591 students provided the 661 students of the engineering/technology education program completers and the 661 students who had not taken any CTAE (career, technical, and agricultural education) course before taking the Georgia High School Graduation Tests. This chapter will summarize the results of the study, draw conclusions based on the data, and provide recommendations for further research.

SUMMARY

The problem of this study was to determine if successful completion of at least two engineering/technology education courses is positively related to students' high school achievement on state mandated standardized tests. There were several hypotheses that were used to find an answer to this problem. These included:

H_{01}: There is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in English/language arts.

H_{02}: There is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in mathematics.

H_{03}: There is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in science.

H_{04}: There is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in social studies.

The significance of this study was to determine if engineering/technology education program completers had significantly better performance on state standardized assessments than students who did not take any CTAE (career, technical, and agricultural education) classes in high school. The engineering/technology education curriculum strives to include the philosophy of ITEEA's Standards of Technological Literacy (ITEA, 2007) and Advancing Excellence in Technological Literacy (ITEA, 2003). It follows the content of each of these documents while integrating the four academic content areas common in all American public high schools (science, mathematics, social studies/history, and English/language arts) and does not focus solely on the direct needs of business, industry, and the workplace. It looks beyond the development of engineers, industrial technologists, or craft workers. As Ritz (2009) stated, "We must seek goals that take curriculum designers and teachers beyond the limits of these specific professions toward the goal of technological literacy for all" (p. 50). The use of practical activities that directly relate to the world outside the classroom tends to increase students' ability to see the connection between academic content and their future; students tend to stay on task (and thus learn) through the active, hands-on approach to learning, thus enabling students and teachers to accommodate different learning rates (Diamond, 2012). Those informal environments that Bell, Lewenstein, Shouse, and Feder (2012) found were effective at supporting student learning are created by the engineering/technology education focus on practical, hands-on projects that call for collaboration between students and often with the teacher as mentor/facilitator rather than taskmaster. Thus engineering/technology education strives to provide the context "...to the situations of life outside the school..." that Dewey (1938) believed was an effective path to teaching students all academic content.

The emphasis on improving student achievement in the core academic areas has led technology education researchers to show linkages between their courses and the core academic areas (Dyer, Reed, & Berry, 2006). Their study of a single high school in Virginia was to determine if there were a significant difference in the scores of the Virginia mathematics Standards of Learning (SOL) end of course test between technology education students and those of students who had not a technology education course. The study showed a positive correlation in mathematics tests scores for first time test takers if they were technology education students. It failed to show a positive correlation for students who were retaking the mathematics SOL and who had taken a technology education course.

The mixed results of the Dyer, Reed, and Berry study, and others provided the impetus for this research into whether completing two courses in the Georgia engineering/technology education curriculum provides an advantage to those students on the Georgia High School Graduation Tests in English/language arts, mathematics, science, and social studies. The information in this study was based on the results of the research data that were obtained from the Georgia Department of Education records of the 2011-12 public high school graduating class ($N = 87{,}591$) in Georgia where engineering/technology education courses were offered. There were a total of 1,322 students who were included in this study. Half of the students were a random sample of students who had completed at least two courses in engineering/technology education (program completers) and the other half were a random sampling of students who had not taken any engineering/technology education courses. The demographics of the studied population mirrored the students in the state's overall graduating class for that year (2011).

All data were acquired from student records that were saved in the state's databases. All data were collected with permissions given by the Georgia Department of Education. Multiple *t*-tests were used to compare the significance of scores in English/language arts, mathematics, science, and social studies for completers and non-completers.

CONCLUSIONS

The purpose of this study was to determine if there were a significant difference between the Georgia High School Graduation Test (GHSGT) scores of students who took at least two courses of engineering/technology education and those who took no CTAE (career, technical, and agricultural education) classes. The study utilized the 2011 Spring administration of the GHSGT tests in English, mathematics, science, and social studies; and compared a random sample of 661 students who had taken at least two courses in the engineering/technology education career pathway with a random sample of 661 students who had not taken any CTAE courses before taking the Georgia High School Graduation tests.

The first null hypothesis, H_{01}, stated there is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in English/language arts. The findings show the mean score for engineering/technology education completers was 244.74. The mean score for non-completers was 236.44. The degree of freedom was 1320. The value of t was determined to be 5.18. This value exceeded the .001 level of significance where $p < .001$. Therefore, the researcher rejects the null hypotheses, H_{01}, and the researcher concludes there is a significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on state mandated standardized tests in English/language arts greater than for those students who did not take any career, technical and agricultural education (CTAE) courses.

The format of most engineering/technology education courses tends to focus on student-centered learning whereby students are required to read complex (word) problems and develop solutions that are not lock-step answers. Students are expected to read, analyze, and then research solutions to meet specific requirements given by the teacher. As Standards for Technological Literacy (STL) lists in its benchmarks topics for high schools, students are expected to document and communicate processes and procedures, collect information, and judge its quality (ITEA, 2007). These topics led to improved reading comprehension and effective writing.

The results of this study differ from the findings of the Frazier study that measured Virginia Standards of Learning (SOL) standardized test scores of English/language arts students enrolled in technology education courses as compared to students who were not enrolled in technology education courses. According to Frazier (2009), students who took Virginia technology education courses had equivalent scores on their English/language arts standards tests (SOL) as students who had not taken technology education courses. Additionally, Bolt (2005) found no significant difference between English/language arts SOL scores of 277 eighth graders who had taken technology education courses and 263 students who had not taken technology education classes. Therefore the researcher concludes that additional studies, with larger populations, should be conducted to ascertain whether this study is an outlier or whether the earlier studies were not wide enough in scope to show a statistically significant difference between engineering/technology education and its impact on English/language arts student statewide assessments.

The second hypothesis, H_{02}, stated there is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in mathematics. The findings show the mean score for engineering/technology education completers was 248.00. The mean score for non-completers was 246.63. The degree of freedom was 1320. The value of t was determined to be 0.46. This value did not exceed at the .001 level of significance where $p = 0.646$. Therefore, the researcher fails to reject the null hypotheses. There is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on state mandated standardized tests in mathematics.

These results are different from the findings of both Frazier (2009) and Dyer et al. (2006) where both studies found some level of improvement in mathematics scores among those students who had taken a technology education course in comparison to students who had not taken technology education courses. According to Dyer et al. the 89 students who took the illustration and design technology education courses passed their Algebra I and Geometry standards tests (SOL) at a higher rate than did the 907 students who had not taken an illustration and design technology education course. Frazier found that a random sample of 50 students who had taken technology education courses were more likely to score higher on the Virginia SOL in mathematics than the random sample of 50 students who had not taken a technology education course. Tran and Nathan (2010) investigated whether students enrolled in Project Lead the Way (PLTW), a national, commercial, technology education curriculum, improved their scores on a Midwestern state's standardized assessment on 10th grade mathematics and discovered an inverse relationship whereby the 70 PLTW subjects had less of a change in mathematics scores from their eighth grade mathematics assessment than those 70 students who had not taken the PLTW content. This current study incorporated a much larger study population than previously published studies and it did show a small, but not significant, gain in mathematics scores. The researcher concludes that currently it cannot be argued that engineering/technology education provides a significant, positive benefit for student scores on statewide assessments in mathematics. Additionally, focused research on specific curriculum, such as Project Lead the Way or Engineering by Design, on a statewide or national level would provide a better understanding of whether there is any positive correlation between a specific aspect of engineering/technology education and student statewide mathematics assessment scores.

Students are provided ample opportunity, due to the format of most engineering/technology education courses, to use basic and advanced mathematics to help solve technical problems. Students are expected to analyze a situation and calculate forces and measurements before completing an engineering solution to a given situation. Students are then expected to research solutions to meet specific requirements given by the teacher, as Standards for Technological Literacy (STL) encourages students to use data and mathematic calculations to improve processes and systems (ITEA, 2007). These actions lead to improved mathematics literacy and skill.

The third hypothesis, H_{03}, stated there is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in science. The findings showed the mean score for engineering/technology education completers was 252.09. The mean score for non-completers was 241.71. The degree of freedom was 1320. The value of t was determined to be 5.98. This value exceeded the level of significance where $p < .001$. Therefore, the researcher rejects the null hypotheses, H_{03}; and the researcher finds there is a significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on state mandated standardized tests in science.

The findings correlate with Frazier (2009) who also saw improvement among his population of students who had completed technology education courses over the students who had not taken technology education classes. The findings of Tran and Nathan (2010) in their Project Lead the Way (PLTW) study again showed an inverse relationship to test score improvements in science, albeit at a less negative rate than they found for mathematics. The explanation for the decrement in PLTW students was hypothesized to be due to the emphasis on collaborative design, engineering skills such as drafting, computer-aided design (CAD), measurement, and fabrication that may interfere with the analytical and abstract exercises that typically make up math and science assessments. The researcher included schools that used Project Lead the Way, Engineering by Design (EbD), or other curriculum and found a significant positive correlation statewide between engineering/technology education and student scores in science on statewide assessments. The researcher also concludes that additional research at the state or national level would help validate the actual correlation between any specific curriculum and student scores on statewide assessments in science.

The format of most engineering/technology education courses permits teachers and students to delve into the problems of the world around them. Thus both physical sciences and biological sciences are possible topics for projects. Students are expected to utilize their understanding of scientific principles in order to reach conclusions and design solutions to technical problems, as Standards for Technological Literacy (STL) recommends for high school students (ITEA, 2007). This additional exposure to the value of the sciences tends to improve student scientific literacy.

The fourth research hypothesis, $H_{04,}$ stated there is no significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on the state mandated standardized test in social studies. The findings show the mean score for program completers on the GHSGT social science tests was 246.37, while the mean score for students who had taken no engineering/technology education courses was 238.04. The degree of freedom was 1320.

The value of *t* was determined to be 3.30. This value exceeded the level of significance at the .001 level of significance where $p = 0.446$. Thus the researcher rejects the null hypotheses, $H_{04;}$ and the researcher finds there is a significant difference between a student completing at least two engineering/technology education courses with the student's high school achievement on state mandated standardized tests in social studies.

The findings correlate with Frazier (2009) who also saw improvement among his population of students who had completed technology education courses over the students who had not taken technology education classes. However, a 2007 study of a Virginia high school found no correlation between taking a technology education course and scores on the Virginia social studies SOL (Creecy, 2007). This researcher concludes that a significant difference exists between students who take a sequence of engineering/technology education classes and their scores on statewide assessments in social studies, and the effects of a single course may not be sufficient to show a correlation, as Israel, Myers, Lamm, and Galindo-Gonzalez (2012) found in their study of the impacts of CTE courses on Florida's Comprehensive Assessment Test (FCAT) in science and mathematics.

The engineering/technology education courses must also direct students to see how technology impacts society and how society impacts technology, concepts that can only be comprehended by an understanding of social studies. Students are expected to explore the history of a problem, its previous solutions, and the impacts of those solutions on society and then design a new solution to meet specific requirements given by the teacher, as Standards for Technological Literacy (STL) (ITEA, 2007) recommends. This research into the impacts of society and technology on each other tend to improve student understanding of social science issues.

Overall, the results of this study show there is a significant difference between students completing a two course sequence in engineering/technology education and their scores on the Georgia High School Graduation Tests in three of the four subjects tested - English/language arts, science, and social studies. Although the difference was not significant, there was also an improvement in mathematics test scores for those students.

Recommendations

Based upon the research findings and conclusions of this study, the researcher includes several implementation recommendations. The first recommendation is that the rigid design of high school schedules should be re-examined. Students enter high school required to take a class during most scheduled class meeting periods. Students are locked into taking a class during a given block of time regardless of whether the student requires, or is interested in, any of the classes offered during that period. Students are additionally faced with having to make decisions about which desired class, or classes, must be forgotten because the courses are only offered at the same time and thus cannot all be selected. The researcher has seen that students have to opt out of an advanced class in one subject in order to take another class that included equally desirable content. Additionally the demands of extra-curricular activities such as band and athletics carry implicit requirements, such as weight training classes and advanced music courses, in order for the student to be a member of the team or group. These conflicts are institutionalized constraints that make the task of a student becoming a career, technical, and agricultural education (CTAE) program completer very difficult for athletes, band members, and profession-bound students who would benefit from a deeper understanding of the opportunities found in the careers encapsulated in CTAE programs. The researcher recommends that high schools adopt a model closer to that of a college, with gaps in the school day for students to either take a desired course or use that time for either school activities or work. Teachers would be given a more expansive schedule that saw them teaching the same number of classes, but at a time more convenient for both students and instructor. This recommendation would require additional accommodations for transportation and student support, but it would provide a means for students to enroll in courses that interest them and support their long-term educational goals.

Additionally, school guidance departments should be made further aware of regulations mandated by the state that prescribe the requirements for a student to become an engineering/technology education program completer. The school guidance counselors should be provided with yearly training on the sequences of engineering/technology education and other CTAE courses in order to meet the requirements for program completion status. The researcher also recommends that efforts should be made to schedule students to have sequential engineering/technology education courses as early in their high school years as possible. Engineering/technology education courses integrate content from the core academic subjects and explore it with practical, hands-on, real-world applications and contribute to students' application of academic content.

If STEM (science, technology, engineering and math) is going to be more than an economic word of the times, then a third implementation recommendation is for the state to create a common planning/collaboration time during the school work period in order to facilitate integration between academic subject teachers and engineering/technology education teachers. Properly organized and led planning sessions would permit worthwhile collaboration that is not constrained by repetitive conflicts with issues not directly related to classroom instruction. The emphasis on improving student achievement in the core academic areas has led engineering/technology educators to show linkages between their courses and the core academic areas (Dyer, Reed, & Berry, 2006). The conflicting demands for administrative assignments and teaching makes it very difficult for engineering/technology education teachers and core subject teachers to collaborate and become familiar with similarities between content that they teach to their students. If these teachers could have the opportunity to collaborate, it may be possible to establish alignments between subjects and provide the engineering/technology education teachers the opportunity to further plan to reinforce the core subject's content. This collaboration would contribute to making the content more relevant to students and promote further understanding for the teachers involved.

A fourth implementation recommendation is for the nation to follow the recommendations of the International Technology and Engineering Educators Association (ITEEA) and add engineering/technology education as a mandatory subject in all K-12 levels. The establishment of sequential engineering/technology education courses for the elementary grades, where the integration of content is obvious, should be an advantage to student learning. In September 1990 technology education became a compulsory subject in the United Kingdom for all pupils age 5-16. Teachers of all subjects are required to include design and technology into their lessons where it is paired with information technology to create the foundation subject area of engineering/technology education (Atkinson, 1990).

Recommendations for Further Research

The Standards for Technological Literacy (ITEA, 2000) provide a basis for a national engineering/technology education curriculum. Although engineering/technology education programs at individual schools differ widely in how the schools and the teachers implement its recommendations, a study of the actual engineering/technology education curriculum taught in schools and its effectiveness on student learning would be a rich topic for exploration.

Additionally, a comparison study between the effectiveness of Project Lead the Way and Engineering by Design on student statewide assessments could also prove valuable, as these two programs provide robust assistance to the teachers for lesson planning and content. This comparison would also provide school administrators a valuable means to determine which program meets the needs of their local community.

Finally, a qualitative study of engineering/technology education K-12 teachers to ascertain their impressions of the how well they find their students to be prepared for the engineering/technology education curriculum, whether the faculty feels their individual programs are adequately funded across all funding sources, and what challenges the faculty faced as they began using their curriculum for the first time, would provide local, state, and national leaders with valuable information to determine the way forward for the engineering/technology education profession as it progresses into the middle 21st century.

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APPENDIX

Sample Data Table from Georgia Department of Education

SCHOOL_ YEAR	SYSTEM _ID	SCHOOL _ID	SEQ_NO	COURSE_NUMBER	COURSE_ SECTION	MARKING _PERIOD	NUMERIC_ GRADE
2010	633	2056	030875	48.5410099	052	S2	94
2010	781	0101	016909	48.5410081	022	S1	92
2010	781	0101	016909	48.5410082	042	S2	87
2010	675	0101	067773	48.4420000	005	S2	77
2010	675	0101	067773	48.4420003	005	S1	79
2010	741	0201	083383	48.4610000	001	S2	94
2010	623	0109	035743	48.5610000	002	S1	94
2010	660	0191	006285	12.4460000	001	Y1	81
2010	633	0373	072784	12.5460099	001	S1	90
2010	640	0196	011048	48.5450020	001	S1	86
2010	721	2056	046518	12.4450080	003	Y1	91
2010	741	0201	083928	48.4410000	003	S2	90
2010	754	0105	003048	48.5810000	003	S1	82
2010	721	2056	043093	12.4450080	003	Y1	77
2010	601	0103	000052	48.5610014	004	S2	99
2010	741	0387	083854	48.4610000	002	S2	80

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