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A Comparative Study of Two Graduation Pathways: Traditional vs. STEM at a Southeastern High School

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Approval Page

This dissertation was submitted by Chemisi Asha Kogo-Masila under the direction of the persons listed below. It was submitted to the Gardner-Webb University School of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Gardner-Webb University.

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Dedication

This work is dedicated to two great and dear people who are no longer with us. Cindy, you will always be in our hearts and will never be forgotten. Mwalimu Chemisi, my Aunt, mentor, whom I miss dearly, your inspiration, encouragement, and support drove me to be who I am today.

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Abstract

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This mixed-methods study approach investigated the impact of standardized tests on student achievement from the STEM program and the traditional program in a suburban high school. Qualitative data were collected from interviews, focus groups, and questionnaires to get perceptual data from teachers. Quantitative data were collected from different demographic information and the standardized tests American College Testing (ACT) and end-of-course examination (EOC). An independent sample *t* test, the Chi-Square Test of Independence and Pearson R Correlation of association test were used to analyze the data collected. Documents with the graduation rates for the participants were reviewed, and both programs had a 100% graduation rate. The results of the survey were presented in tables and figures and then interpreted using the results of the statistical tests.

Results from this study showed there was no statistically significant difference in the mean average for ACT, Biology, Math I and English II scores. This led to the conclusion that there were no statistically significant differences in the achievement and graduation rate of students who were in STEM and traditional programs. The results for ACT, Biology, and Math 1 favored the STEM students; while the results for English II favored the traditional students. The qualitative data from teachers who were surveyed and those who participated in the focus groups and individual teacher interviews showed there was an association in student achievement based on the professional development activities in which the STEM teachers participated. Also, the participating teachers had a positive perception regarding the overall impact of the STEM program. The study showed the rigorous and challenging STEM curriculum increased motivation, engagement, achievement, and self-efficacy among the STEM students. Staff development and in-service training for the STEM teachers led to teacher self-efficacy and equipped them with the ability to instruct and facilitate instructions in STEM classrooms effectively.

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Chapter 1: Introduction

The term "STEM education" has been referred to by the Congressional Research Service (2012) as teaching and learning in the fields of science, technology, engineering, and mathematics (STEM). Federal policymakers have shown an increased interest in STEM education which has seen more than 200 bills containing the term "science education" introduced between 100th and 110th Congresses which took place between 1987-2009. Despite this interest, concerns remain with the ranking of U.S. students on international assessments. The National Center for Education Statistics (NCES, 2012) showed the 2012 Program for International Student Assessment (PISA) results which ranked American students 23 of 65 countries in the world in science assessment and 35th in the world in math assessment (Appendix A). In the today's global economy, knowledge in STEM fields has become a crucial issue in the creation of many occupations (National Research Council [NRC], 2011). The U.S. falls short in preparing students for the different occupations requiring STEM knowledge. In response to this, the National Resource Council (2011) report points the importance of developing new strategies to increase the number of students in STEM education, especially students from historically underrepresented populations.

In the U.S. Senate Report (2011), four key recommendations were presented: (a) increase achievement of the U.S. K-12 education system in science and mathematics to a leading position by global standards; (b) sustain and strengthen the long-term commitment to basic research; (c) encourage more U.S. citizens to pursue careers in mathematics, science, and engineering; and (d) rebuild the competitive ecosystem. Of these recommendations, education in the STEM discipline has received the most attention. The U.S. Senate Report (2011) concluded the primary driver of the future economy and creation of jobs in the 21st century would be innovation largely derived from advances in science and engineering.

Background of the Problem

The National Academies of Science, Engineering, and Medicine (2015) outlined three goals for K-12 STEM education in the U.S.: (a) expand the number of students who pursue advanced degrees and careers in STEM fields; (b) increase the participation of women and minorities in STEM fields; and (c) increase STEM literacy for all students including those who do not pursue STEM disciplines. The last goal is similar to one of the three goals for K-12 education outlined in the Report of the Academic Competitiveness Council (U.S. Department of Education, 2007), which stated to prepare all students with STEM skills required to succeed in the global world.

There has been an increase of STEM programs in high schools across the U.S. STEM programs integrate the four disciplines into a cohesive program based on real-world application. Despite being a leader in the past, data from the U.S. Department of Education (2010) indicated only 16% of high school students are interested in a STEM career. Twenty-eight percent of high school first-year students have an interest in a STEM-related field, and 57% of these students lose interest by the time they graduate from high school. Several STEM programs have been designed by different school districts to meet the goals of K-12 STEM education in the U.S. (U.S. Department of Education, 2014).

Statement of the Problem

The decline in the ranking of U.S. education to 36 of 65 countries on PISA has stimulated interest in creating and implementing STEM programs across the country. The report from STEMconnector and My College Options (2013) indicated that many high school students lose interest in STEM. American College Testing (ACT) research also suggests that student interest in these fields is on the decline (Appendix B). Over the past 10 years, the percentage of ACT-tested students who said they were interested in majoring in STEM fields dropped steadily from 7.6% to 4.9%. This is contrary to the fact that job opportunities in the STEM fields are expected to increase significantly in the coming years. Despite this, teen interest in STEM fields is also declining. The Junior Achievement USA and ING (2013) survey where 1,025 teens were asked about their career plans showed a decrease of 15% from the 2012 survey when 61% of the students considered STEM as their top choice.

Federal funding for STEM education has increased to almost $3 billion. School systems continue to introduce and implement STEM programs, yet little is known about the relationship of the program to student achievement in standardized tests to justify the increased funding. There is a lack of research documenting STEM school programs, teacher training, student achievement, and graduation rates from high school. The problem is compounded by the lack of instruments of demonstrated validity and reliability to measure important outcomes of STEM education (National Science Foundation [NSF], 2011).

To address the current status of STEM programs in the U.S., several STEM high schools have been created and are currently operating all over the U.S. (NRC, 2011). This is a step forward to address the issue, despite there being little research available to document the effectiveness of the program using standardized tests to determine the level of student achievement (NRC, 2011). This creates a need to gather information from a current STEM program in a suburban high school with both the traditional program and the STEM program and compare how the two groups perform using standardized tests as indicators. The findings of this study will help school districts considering the development and implementation of STEM programs in evaluating effective strategies that make the program successful.

Information that will be helpful to educational leaders in starting new STEM programs includes population served, criteria used to select the students, staff development that the STEM teachers undergo that are not available to the traditional program teachers, performance on achievement tests, and teaching methods used. Education leaders planning to begin a STEM program will benefit from the research based on the outcome using the standardized tests as indicators. This study will provide school leaders with the relevant information to open more STEM schools, justify the allocation of resources to STEM programs, and determine if the program will be beneficial to the entire school population and not only those who meet the selection criteria to join the STEM program.

Theoretical Framework

The study was influenced by two theories: Bruner's (1966) Discovery Learning Theory and American physician and medical educator Barrows's (1986) Problem-Based Learning (PBL). Bruner, an American psychologist and a cognitive learning theorist, promoted an example of cognitivism referred to as Discovery Learning. The constructivist view is that the learner creates understanding through personal experience and interaction with external stimuli (Bruner, 1966). Bruner's (1966) theory focuses on the belief that active engagement by students including experiments, exploration, and knowing the world around them leads to knowledge development. This, in turn, leads to motivation and creativity in developing problem-solving skills.

PBL addresses the need to promote lifelong learning through the process of inquiry and constructivist learning. It can be considered a constructivist approach to instruction, emphasizing collaborative and self-directed learning (Schmidt & Moust, 2000). The use of PBL has been motivated by recognition of the failures of traditional instruction and the emergence of a deeper understanding of how people learn (Caswell, 2015). As a strategy, PBL attempts to get students to apply knowledge to new situations by developing critical thinking and creative skills, improving problem-solving skills, increasing motivation, and helping students learn how to transfer knowledge to new situations.

The effects of the STEM PBL approach are varied and include positive attitude towards learning, team communication, collaborative behavior, increased student interest, self-confidence, and self-efficacy (Baran & Maskan, 2010; Dominguez & Jaime, 2010). The approach used in STEM education encourages students to be motivated, creative, and develop problem-solving skills. The constructivist theory will influence the teaching methods used in STEM programs.

Research Questions

The study was guided by the following questions.

1. To what extent is there a statistically significant difference in the achievement of students who are in the STEM program as opposed to students in the traditional program?
2. To what extent is there a statistically significant difference in the graduation rate of students who completed the STEM program as opposed to students in the traditional program?
3. To what extent is there an association between the professional development activities of STEM faculty and student achievement?

4. What perception do teachers have regarding the overall impact of the STEM program?

Research Purpose

The goal of this mixed-methods research was to gain an in-depth understanding of the impact of the0 STEM program on student achievement. The end-of-course (EOC) state assessment and standardized test ACT were used as the academic achievement indicators. The information was used to determine the graduation rate of the STEM students and the traditional students. Mixed-methods research uses both qualitative and quantitative research. Mertens (2010) mentioned that mixed-method research is of particular value in education-related research. Creswell (2014) noted that mixed-methods research can balance biases found in other research methods and allow for triangulation of data providing a solid foundation to research.

The study used concurrent mixed methods where the quantitative and qualitative data were collected roughly at the same time. The data were then merged to provide a comprehensive analysis of the research problem (Creswell, 2014). "Concurrent mixed method data collection strategies have been employed to validate one form of data with the other kind, to transform the data for comparison, or to address different types of questions" (Creswell & Plano Clark, 2007, p. 118). To be able to gain perspective on how the STEM and the traditional programs perform on standardized tests as well as to understand how teacher training, instructional strategies, and professional development offered to teachers affect student achievement, it was important to utilize a mixed-method approach.

Definition of Terms

STEM program. A curriculum based on instructing students in four disciplines:

science, technology, engineering, and mathematics. It is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons. Students apply science, technology, engineering, and mathematics in contexts that make connections to real life situations enabling the development of STEM literacy and with it the ability to compete in the new economy (Tsupros, Kohler, & Hallinen, 2009).

Magnet schools. Public schools that exist outside of zoned school boundaries offering specialized curriculum focus not available elsewhere in the school district. They are designed to attract a more diverse student body from throughout a school district with similar educational interests and provide a unique set of learning opportunities. Magnet schools have a focused theme and aligned curricula in STEM, Fine and Performing Arts, International Baccalaureate, International Studies, and World Language immersion and non-immersion. Most magnet schools have specific academic entrance requirements; others use a random computer-based lottery system for admission (U.S. Department of Education, 2004).

Traditional schools. Schools that are maintained at public expense for the education of the children in a district. The schools are funded and controlled by three levels of government: the U.S. Department of Education on the federal level, state level departments of education, and the school district at the local level (Tourkin et al., 2010).

Curriculum. A term used to refer to the lessons and academic content taught in a school or a particular course or program. It is the knowledge and skills students are expected to learn, which include the learning standards the students are expected to learn. "It is the totality of learning experiences provided to students so that they can attain general skills and knowledge at a variety of learning sites" (Marsh & Willis, 2006, p. 11).

Student achievement. An indicator used to measure the amount of academic content a student learns in a determined amount of time. Each grade level has learning goals that educators are required to teach. Student achievement will increase when the quality instruction is used to teach instructional standards (Marzano, Pickering, & Pollock, 2001).

Assessment. Refers to the different methods or tools educators use to evaluate, measure, and document the academic readiness, learning progress, and skill acquisition or education needs of students as a result of their educational experiences. It is a critical tool of differentiated instruction that helps to identify the most effective strategies and activities that will encourage student learning (Ontario, Ministry of Education, 2010).

Graduation rate. The percentage of students who have completed high school within 4 years of their entry into ninth grade as measured by annual cohort. High schools and school districts are held accountable for their graduation rate for the purpose of determining Adequate Yearly Progress (AYP) by the state and federal government (NCES, 2016).

PBL. An instructional method of hands-on active learning centered on the investigation of real world problems. Learning is driven by challenging, open-ended questions with no right answers where students work as self-directed, active investigators and problem solvers in small collaborative groups (Boud & Feletti, 1997).

Professional development. A broad range of specialized training, formal education, or advanced professional learning intended to help administrators, teachers, and other educators improve their professional knowledge, competence, skill, and effectiveness (Jasper, 2006).

Student engagement. Refers to the degree of attention, curiosity, interest, optimism, and passion demonstrated by students when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education (Willms, 2003).

School culture. Refers to the beliefs, perceptions, relationships, attitudes, and written and unwritten rules that shape and influence every aspect of how a school functions. Culture encompasses traditions and ceremonies schools hold to build community and reinforce their values (Peterson & Deal, 2009).

Self-efficacy. People beliefs about their capabilities to perform tasks and influence outcomes of events that affect their lives. Self-efficacy beliefs determine how people feel, think, motivate themselves, and behave (Bandura, 1997).

Delimitation and Limitation of the Study

The delimitation for this study is the fact that the study was conducted in one high school in North Carolina. Due to the nonprobability nature of sampling, external validity was limited to study participants. The first limitation of the study is the size of the population. Internal validity was affected as random assignment was not conducted with students in the STEM program due to there only being approximately 100 students per grade level. The second limitation is the number of years since the program was established. Using data 4 years old when the first STEM group was in ninth grade presented a limitation in generalizing in the current use.

Significance of the Study

The study will be valuable by providing school systems, administrators, teachers, and other stakeholders in the community an insight into the STEM program comparative data on student achievement on EOC assessments and ACT for students in the STEM program versus students in the traditional program. An analysis of data gathered from documents, surveys, and interviews with teachers and students provided information necessary in expanding STEM programs in high schools. Results from the study may provide support and documentation to continue funding and to expand STEM programs.

Summary

A STEM program in a suburban high school offers the program to students who meet the eligibility requirements. The school continues to offer a tradition high school program to the rest of the students. A mixed-method approach was used to gather different data using documents, surveys, and interviews with teachers. The purpose of the study was to determine how effective the STEM program was compared to the traditional program. The standardized tests, EOC and ACT, were used as achievement indicators. The results of this study will be relevant to key stakeholders by providing an insight of the STEM programs in high schools and providing support and documentation for the purpose of funding and expansion of the program.

Chapter 2 presents a review of literature starting with the history of the STEM program in the U.S. and the different policies and publications that have influenced the program. To better understand the differences between the STEM and traditional programs, a detailed definition of the programs is done. Also, the literature review contains a summary of documented research on the STEM program by other researchers and their impact on academic achievement. This will highlight the progress that has been made toward achieving the goals of the STEM program in the U.S.

Chapter 2: Literature Review

Introduction

Wagner (2012) stated that the country's economic problems are based in its education system. The nature of education today is that it is ubiquitous, constantly changing, and growing exponentially. America's last competitive advantage is its ability to innovate. Wagner (2010) defined the skills needed for Americans to stay competitive in an increasingly globalized workforce as "the set of core competencies that every student must master before the end of high school" (p. 14). The seven core competencies are (a) critical thinking and problem solving; (b) collaboration and leadership; (c) agility and adaptability; (d) initiative and entrepreneurialism; (e) effective oral and written communication; (f) accessing and analyzing information–information is constantly changing and growing; and (g) curiosity and imagination–innovation and creativity.

The changing nature of education requires students to be proficient in transferring knowledge and skills, and problem solving is a critical skill for students to learn to adapt to a changing world that supports the seven sets of core competencies. Problem solving is one of the instructional strategies employed in teaching the STEM program. According to Mayer and Wittrock (2006), problem solving is "cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver" (p. 287). Based on the definition, problem solving consists of four parts: (a) problem solving is cognitive; (b) problem solving is a process; (c) problem solving is directed; and (d) problem solving is personal, that is problem solving depends on the knowledge and skill of the problem solver.

Literature identifying teacher training in STEM education, skills that students need to succeed in STEM education, and careers related to STEM education and STEM-focused schools are abundant. The effectiveness of the STEM program using assessment indicators like EOC state exams and the ACT in high schools is lacking. The purpose of this review was to provide a background for this research by contextualizing the literature on the effectiveness of the STEM program using standardized assessments as indicators. To adequately examine the research, it is important to give attention to the history of STEM education. Providing a brief overview of the history of STEM education provides a contextual understanding of the need for more research on STEM teaching and high school achievement.

History of STEM Education

The history of STEM in the U.S. dates back to the mid-1990s over the heated controversy known as “The Mathematics Wars” (Schoenfeld, 2004). The teaching of mathematics was in the center of the controversy traced back to the reform stimulated by the National Council of Teachers of Mathematics’ Curriculum and Evaluation Standards for School Mathematics. The traditionalists feared the reform-oriented, “standard based” curricula were superficial and undermined classical mathematical values. On the other hand, the reformers claimed that such curricula reflected a deeper, richer view of mathematics than the traditional curricula (Schoenfeld, 2004). This led to the idea of integrating content in a problem-centered environment with a variety of sources, some as far back as the 1920s. John Dewey viewed the role of a teacher as a facilitator using inquiry method, problem solving, and integrated curriculum. His concept of instrumentalism in education on “learning by doing” explained that people learn best through experience and advocated for inquiry-based education. His emphasis was that active curriculum should be integrated rather than divided into subject-matter segments (Brewer, 2007).

It is important to understand that curriculum integration is an idea that has a strong historical background. Disciplines were created in an attempt to organize the world around them; sometimes this was motivated by political means (Beane, 1991). It was not until the USSR launched *Sputnik*, the first space satellite in 1957, that the efforts of the early advocates of PBL received attention. This was viewed as a major humiliation to Americans which prompted attention to the low quality of mathematics and science instruction in the US. This led to Congress passing the 1958 National Defense Education Act to increase the number of science and math majors (Klein, 2003b).

Recently, attention to the K-12 curriculum and instruction regarding the quality of mathematics and science has led to several publications. *Before It's Too Late* (U.S. Department of Education, 2000) was written by the National Commission on Mathematics and Science with the message that America's students must improve their performance in mathematics and science to succeed in today's world. The U.S. Department of Education (2007) also aimed to improve America's competitiveness in STEM education by laying the groundwork for sustained collaboration among STEM education program and federal agencies.

Several other bills have been passed to ensure the U.S. maintains a global leadership position in science, technology, and innovation. They include America Competes Act (Civic Impulse, 2015) and American Recovery and Reinvestment Act of 2009 which includes $2.5 billion in funding for NSF and STEM education program; STEM Education for the Global Economy Act of 2015; and Klobuchar and Hoeven's (2015) STEM legislation among others. All these bills were passed to ensure that the U.S. stays competitive in the 21st century economy by adequately preparing students for future jobs. This is by increasing quality STEM education which is an important component in the education of American students (Klobuchar & Hoeven, 2015).

Policies and Publications Influencing STEM

States and federal initiatives and funding play a significant role essential to quality education for all American children. The section highlights different government policies and reports that have influenced public education in the U.S. *A Nation at Risk* (1983) cited a decline of the educational system in America with high school student performance in the U.S. and other countries as an indicator. The report identified specific problem areas and offered multiple recommendations to increase high school graduation requirements, one of which was to increase the number of years for mathematics and science to 3 years. The report also highlighted the shortage of qualified mathematics and science teachers.

In September 2000, the report titled *Before It's Too Late* was released by the National Commission of Mathematics and Science (U.S. Department of Education, 2000). In the report, it was noted that for the U.S. to stay competitive in the global economy, America's students must improve their performance in mathematics and science. Goals for improvement were stated as follows: (a) improve the quality of mathematics and science teaching in Grades K-12; (b) increase the number and quality of mathematics and science teachers; and (c) improve working conditions for teachers to make the profession more attractive for mathematics and science teachers.

The federal legislation act that effectively scaled up the federal role in holding schools accountable for student outcomes was the No Child Left Behind ACT of 2001 (U.S. Department of Education, 2003). The act required states to develop assessments in basic skills to be given to all students if those states are to receive federal funding for schools. The bill sought to advance American competitiveness and close the achievement gap between poor and minority students and their more advantaged peers. Four pillars were emphasized within the bill by NCLB (U.S. Department of Education, 2003):

1. States to ensure that disadvantaged students achieve academic proficiency.
2. Allow school district flexibility in how they use federal education funds to improve student achievement.
3. Emphasize educational programs and practices that have been proven effective through scientific research.
4. Increase choices available to the parents of students attending Title I schools.

This legislature does not specifically target STEM education but has had a significant impact on U.S. education.

The National Governors Association (NGA, 2007) released a final report depicting the role of governors in establishing best practices in education. Three core strategies were identified: improving STEM education, aligning state K-12 STEM standards with state economies, and encouraging regional economic growth. Obstacles to these core strategies related to STEM were identified as

1. Many high school graduates are not prepared for postsecondary education.
2. Lack of alignment between K-12 postsecondary skills and expectations.
3. Shortage of STEM teaching workforce due to attrition, migration, and retirement.

A workforce of problem solvers, innovators, and inventors is essential to drive innovative capacity in a state. A key to developing these skills is by strengthening STEM competencies in K-12 grades in school (NGA, 2007).

The Every Student Succeeds Act (ESSA; U.S. Department of Education, 2015) built on the main areas of progress in education made in recent years. The act saw the end of NCLB by restoring to states the responsibility for determining how to use federally required tests for accountability. The law is divided into eight different titles, each aimed at strengthening and supporting the educational systems of state and Local Education Agencies (LEAs). The titles of the law are:

1. Title I – Improving basic programs operated by state and LEAs
2. Title II – Preparing, training, and recruiting high-quality teachers and other school leaders
3. Title III – Language instruction for English learners and immigrant students
4. Title IV – 21st century schools
5. Title V – State innovation and local flexibility
6. Title VI – Indian, Native Hawaiian, and Alaska Native Education
7. Title VII – Impact aid
8. Title VII – General provisions

In addition to the titles, the law has provisions, some of which are a continuation of the NCLB requirements. An example is to continue with the NCLB requirement that states have in place for academic content and achievement standards. The only difference from NCLB is that the standards must be the same for all students.

The STEM Education Act of 2015 is an amendment of the NSF Act of 2002. The Act of 2002 limited the award of NSF Master Teaching Fellowship to mathematics and science teachers with a master's degree and not bachelor's degree. The new law allows the award to bachelor's degrees. The STEM Education Act of 2015 requires NSF to continue to award competitive merit-reviewed grants to support (a) expanding research and training opportunities for math and science teachers through NSF, (b) boosting research that advances the field of informal STEM education, and (c) incorporating computer science into the definition of STEM education. The bill was supported by the STEM Education Coalition (2015), stating, “The STEM Act is a good starting point to ensure that federal education and workforce programs are aligned with the needs of today’s students and our future economy” (para. 1).

The reports and the laws described above were designed to bring attention to the need for improving education in the U.S. Suggestions made have led to the implementation of new programs with the STEM program being one of them (President’s Council of Advisors on Science and Technology [PCAST], 2009).

Occupational Careers Related to STEM Program

Different publications and reports have highlighted the importance of STEM education. One report is by Connections Learning which emphasized that STEM education will be beneficial to students due to the STEM fields expanding more quickly. By 2018, 1 in 20 global jobs will be STEM related which is an estimated 2.8 million jobs. STEM-related skills are not just a source of jobs but are a source of employment that pay very well (Figure 1). A report from Georgetown University Center on Education and workforce found that 65% of those with bachelor’s degrees in STEM fields earn more than those with master’s degrees in non-STEM occupations. The number of jobs available in any nation fuels its economy. According to the U.S. Labor Department, STEM careers are among the nation’s fastest growing fields with the 10 fastest growing occupations from 2008-2018 being STEM occupations (Science Pioneers, 2010).

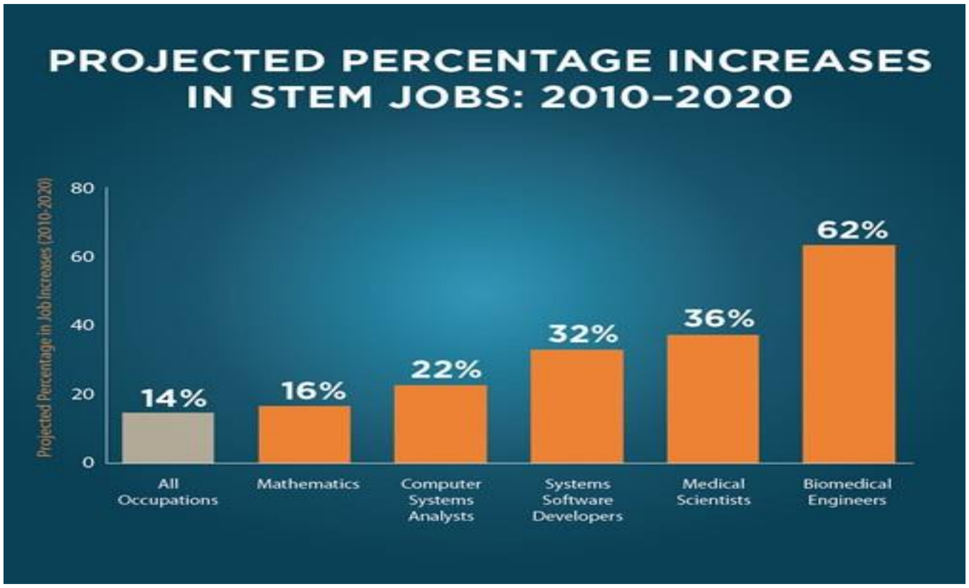


Figure 1. Projected Percentage Increase in STEM Jobs.
Source: U.S. Department of Education (2010).

Careers related to STEM are very diverse, and the top 10 STEM jobs are Computer Systems Analyst, Software Developer, Web Developer, Accountant, Biomedical Engineer, IT Manager, Financial Advisor, and Information Security Analyst (U.S. News & World Report, 2016). STEM occupations are projected to grow faster than the average for all the professions. Over the past 10 years, growth in STEM jobs was three times as fast as growth in non-STEM jobs (U.S. Department of Commerce, Economics, and Statistics Administration, 2011). In 2010, there were 7.6 million STEM jobs, representing one in 18 workers. STEM occupations were projected to grow by 17% from 2008 to 2018, compared to 9.8% growth for non-STEM occupations. When it comes to earning, workers in STEM occupations earn 26% more compared to their counterparts in other jobs and experience less joblessness (Appendix C).

Strategies for STEM Programs

Instructional strategies in STEM education mainly focus on constructivist approaches, PBL, and making connections to the real world. In the classroom, constructivism is implemented through hands-on activities that motivate students to make observations, ask questions, and at the end develop their ideas. The teacher facilitates instruction by guiding the learning process. Learning is also contextual and only takes place when the learner connects ideas or facts to a larger picture. The PBL is grounded in the constructivist theory that research has proved advances learning (Torp & Sage, 2002). STEM PBL is an interdisciplinary teaching and learning approach that involves hands-on activities, collaboration, team communication, knowledge construction, and formative assessment as the primary components for PBL (Barron et al., 1998). This is in higher level cognitive tasks such as scientific processes and mathematic problem solving. The opportunity to communicate and collaborate with peers and teachers stimulates students to construct their knowledge and make use of formative feedback which is important in STEM PBL classes (Capraro & Yetkiner, 2008).

Projects for STEM PBL are composed of several problems where students apply prior knowledge learned before or at present to find strategies to solve new challenges (Goldman & Petrosino, 1999). Also, the hands-on activities, communication, and collaboration with peers help students develop positive attitudes (Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2001). Multiple research-based approaches to STEM education include Design-Based Science (Fortus, Krajcib, Dershimerb, Max, & Mamlok Naamand, 2005); Math Out of the Box (Diaz & King, 2007); Learning by Design (Kolodner et al., 2003); and Integrated Mathematics, Science, and Technology (Satchwell & Loepp, 2002) among others. All of these approaches incorporate a process of inquiry-based activities with five steps: reflection, research, discovery, application, and communication.

Defining STEM Program

NSF came up with the word STEM as an acronym for science, technology, engineering, and mathematics. Bybee (2010) defined STEM education as an integrative approach to curriculum and instruction. The STEM program aims to change the traditional teacher-centered classroom by having a curriculum that is driven by problem solving, discovery, and exploratory learning and involves active engagement by students. The four disciplines that make up STEM have been taught independently from each other in the past. Science, technology, engineering, and mathematics play an important part in the teaching of the program. The technology component provides the creative and innovative ways to solve problems and application of what has been learned in the STEM program.

The STEM program is fully integrated at an elementary level compared to the higher levels with the students being taught with a single teacher for the most part of the day. At the elementary level, STEM education focuses on the introductory level providing students with awareness about STEM fields and occupations. The level also provides standard-based learning aimed at connecting all four STEM subjects. The course becomes more rigorous and challenging at the middle school level with the exploration of the different STEM careers. The high school level focuses on the application of the subject in a challenging and rigorous way. At this level, pathways and occupations are made available to the students; and preparation for postsecondary education and employment is emphasized at this level.

Several organizations are in the forefront for advocating for policies to improve STEM education at all levels. The STEM Education Coalition is an example of the central mission to inform federal and state policymakers on the vital role that STEM education plays in U.S. competitiveness and future economic prosperity. In the coalition, the annual report of 2014, the "Core Policy Principles" that the coalition embodies and seeks to implement are outlined: (a) STEM education must be a national priority; (b) economic prosperity is linked with student success in the STEM fields; (c) the capacity and diversity of the STEM workforce need to be expanded in the U.S.; (d) all policymakers need to be informed of policy issues related to STEM education; and (e) policies to promote STEM education should be bipartisan and evidence based.

The STEM program teaches independent innovation that allows students to explore different subjects in depth and to utilize the skills learned to help them become competitive globally.

> In the 21st century, Scientific and Technological innovations have become increasingly important as we face the benefits and challenges of both globalization and a knowledge-based economy. To succeed in the new information-based and highly technological society, students need to develop their capabilities in STEM to levels much beyond what was considered acceptable in the past. (NSF, 2007, p. 2)

As the U.S. strives to keep up with the increased need of STEM students and pushing toward holding a competitive edge in a rapidly changing workforce, it is important to keep up with the demand for STEM output. This can be done by ensuring that American students have a solid foundation in the STEM disciplines through a well-rounded curriculum and teachers who are experts in STEM education. Graduates who have studied calculus, engineering, physics, chemistry, biology, and other STEM subjects can be trained to teach STEM classes. Professional development sessions and instruction strategies on how to teach STEM courses are offered to the graduates while on the job.

Professional development offered to STEM teachers on implementing STEM PBL is successful in increasing teacher self-efficacy and improvement of classroom practices (Hmelo-Silver, 2004; Shin et al., 2010). Completion of the professional development enables teachers to use more standards-based teaching practices and informal assessments than they did prior (Zhang, Lundeberg, & Eberhardt, 2011). In addition to the pedagogical content knowledge, 2-year-long activities positively impacted the teaching knowledge of teachers who attended (Garet et al., 2011).

Several professional development resources that can be utilized in the classroom are available to them free of charge. The STEM Education Resource Center provides nearly 4,000 STEM resources for prekindergarten-12. The trainings offered are designed to be used by the teachers at their own time and are self-paced modules that can be utilized by STEM teachers in middle and high schools. National Aeronautics and Space Administration (NASA) is also in the forefront with providing professional development to STEM teachers. NASAePDN, an Electronic Professional Development Network, offers free online professional development to K-12 teachers. The areas focused on include robotics, statistics, project-based inquiry learning, and technology integration (National Education Association, 2015).

The National Academies of Science, Engineering, and Medicine (2015) outlined three goals for K-12 STEM education in the U.S.: (a) increase the number of students who ultimately pursue advanced degrees and careers in STEM fields. It is important to raise the participation of Blacks, Hispanics, and low-income students in the STEM fields to meet this goal; (b) broaden the participation of women and minorities in these areas. This is crucial to the U.S. economy as the current demand for STEM workers is greater than the supply of applicants who have trained in STEM careers; and (c) increase STEM literacy for all students including those who do not pursue STEM disciplines. NRC (2011) defined STEM literacy as knowledge and understanding of scientific and mathematical concepts and processes required for personal decision making.

Definition of Traditional Schools

Traditional schools also are known as public schools that receive government funding as their primary support and provide free public elementary or secondary schooling operated by an LEA (Tourkin et al., 2010). Students are matched by age and possibly by ability level with direct instruction, lecture, listening, and observation being the primary methods of teaching. The focus of the school is on basic education practices with the expectation of mastery in the core subjects and increases in test scores, grades, and graduation rates (Coalition of Education, 2016). Traditional schools are required to admit all students who live in the assigned neighborhood school. The advantages of traditional schools include the use of state-approved standards in all curricular areas; a diverse population which encourages tolerance among students; and social interactions through clubs, sports, prom, homecoming, and pep rallies (Coalition of Education, 2016).

The funding of the traditional schools is through the state and federal government which makes support services like counseling, special education, and speech therapy available for students who qualify. The schools are regulated and monitored by the state which makes sure that teachers are properly trained to teach with most holding a bachelor's degree or higher in addition to being state certified (NCES, 2015). High-quality resources like updated textbooks and technology and elective courses like art, music studies, carpentry, and masonry among others are made available for students. Due to these resources, traditional schools do better in reading and math compared to charter and private schools (NCES, 2015).

Traditional schools operate using the traditional calendar and the year-round or balanced calendar. The traditional school calendar has students in session for 180 days with small breaks during the year and a long summer vacation. The traditional school calendar was developed for two primary reasons: agrarian needs to free students to work in farms and lack of air conditioning (Morison, 2002). Today, the vast population has become urbanized; but still, the educational system has continued to be based on the traditional calendar (Cooper, Valentine, Charlton, & Melson, 2003). Students in the traditional school calendar experience some learning loss during the summer vacation. There was an increased loss of skills among the students and a larger learning gap among students from different socioeconomic backgrounds (Cooper et al., 2003).

According to National Association for Year-Round Education (NAYRE, 2010), the year-round calendar affords students the ability to continue their education uninterrupted and address key learning areas. Year-round schools operate with more breaks which are shorter, unlike the schools that use the traditional school calendar. The year-round calendars provide accelerated programs and advanced classes which studies have shown to be beneficial to high-achieving students (Coalition of Education, 2016).

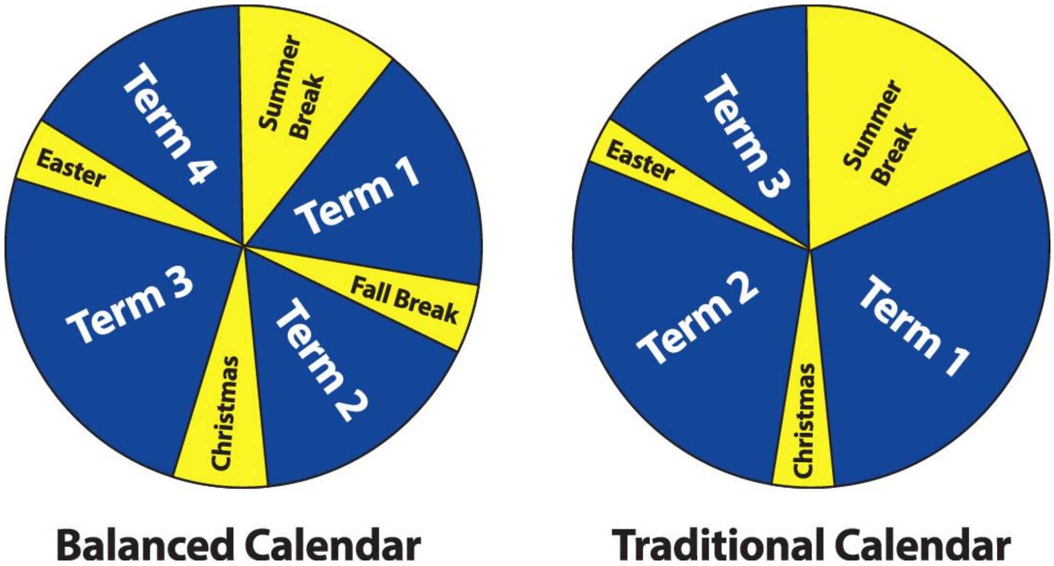


Figure 2. Traditional and Balanced School Calendar.
Source: NAYRE (2010).

Progress toward STEM Goals: Research Influencing High School STEM Programs

The U.S. Department of Education and NSF have continuously supported the development of new approaches to STEM education. NSF has continually been looking to fund projects that will provide a national perspective on programs that support advances in fundamental research on STEM learning and education (NSF, 2015). The projects should involve efforts in developing foundational knowledge in STEM learning and learning contexts from K-16, learning in STEM learning environments, STEM professional workforce development, and research on broadening participation in STEM education (NSF, 2015). Results from the different research will be made available to the public and could impact how STEM programs are designed, the teaching of STEM courses, and preparation of STEM professionals.

A report published by the Harvard Business School highlighted the importance of improving prekindergarten-12 education by committing to an innovative approach

(Grossman & Lombard, 2015). The approach is known as "collective impact" and addresses weaknesses in the U.S. education. The ability of the U.S. to prepare students for college or career will determine its competitiveness in a global economy. This can only be achieved by improving the U.S. public education system (Grossman & Lombard, 2015). The National Math and Science Initiative and the STEM Education Coalition advocate for STEM education to ensure U.S. viability in the world economy. For the U.S. to regain its competitiveness, the importance of STEM education must be emphasized.

The following section of the literature review contains a summary of documented research on STEM programs and their impact on academic achievement. Table 1 is an overview of the studies that were conducted and the results found by the researchers. A description of the different studies follows the table.

Table 1

Research on STEM Education Programs

Participants	Topic	Design	Results
Middle school students	Impact of a STEM Program On Academic Achievement Of Eighth Grade Students.	Ex-post facto casual-comparative research.	Positively impacted academic achievement.
Elementary students	Effect of STEM education on Mathematics achievement of 4th grade minority students.	Quantitative nonexperimental descriptive Comparative study.	STEM education has the potential to improve achievement on standardized assessment.
High school students and teachers	Impact of STEM PBL teacher Professional development on Student mathematics in high schools.	Mixed-method case study.	Low performing students showed statistically significantly higher growth rates. Attendance in PBL significantly correlated with the quality of the in-class PBL implementation. STEM PBL instruction positively influenced Hispanic students' achievement in mathematics.
Elementary	Investigating the effects of integrating Science and and Engineering content and pedagogy in an elementary school.	Mixed-method quasi-experimental study.	Increased student learning and interest in Science.
High school Students	The influences of mathematics self-efficacy, identity, interest and parental involvement on STEM achievement in Algebra for female high school students.	Longitudinal study	Mathematics identity was the strongest predictor of STEM achievement for female high school regardless of race.

High Schools

The Federal Science, Technology, Engineering, and Mathematics (STEM) Education 5-Year Strategic Plan: A Report from the Committee on STEM Education (National Science and Technological Council, 2013) outlined five priority STEM education investment areas. The areas are to improve STEM instruction, increase and sustain youth and public engagement in STEM before completing high school, better serve groups historically underrepresented in STEM fields, and design graduate education for tomorrow's STEM workforce (National Science and Technological Council, 2013). NSF funded several research projects to identify best practices in STEM education in all types of schools. The results indicated that for effective K-12 STEM instruction to become the norm, schools and districts must be transformed.

Howard (2015) investigated the motivational factors and parental involvement associated with female high school student STEM achievement in algebra. This study was influenced by National Assessment of Education Progress (NAEP, 2011) on the achievement gap in the educational setting. Achievement gaps can occur when one group of students outperforms another group and the difference in average scores for each group is statistically significant (NAEP, 2011). Researchers provided information on differences in achievement revealing several unmet goals in minority students and confirming the persistent existence of a gap in achievement (NAEP, 2011). Longitudinal data from national, regional, and institutional databases were analyzed to identify the gender gap in STEM education. Multiple contributing factors related to academic preparation of females were studied by researchers (Ethington & Wolfe, 1988). The obstacles related to academic achievement include perceptions of a lower self-assessment of capabilities for females compared to their male counterparts (Betz & Hackett, 1983;

Brainard & Carlin 1998; Correll, 2001; Feather, 1988; Hyde, Fennema, & Lamon, 1990; Sax, 1994); societal stereotypes (Entwisle, Alexander, & Olson, 1994); and a lack of female role models in STEM as well as family and peer influences (Ost, 2010).

Han (2013) analyzed the impact of professional development on teacher understanding and implementation of STEM PBL. The participants were teachers in three high schools who attended professional development and were required to implement STEM PBL once every 6 weeks for 3 years. Three articles were utilized for this study. The first report employed a mixed-method case study to explore the relation between the quality of teachers in class STEM PBL implementations. Many studies have indicated that professional developments implementing STEM PBL have shown an increase in teacher self-efficacy and improvement of classroom practices (Hmelo-Silver, 2004; Shin et al., 2010). Teachers who attended and completed the professional development reported an increased ability to use more standard-based teaching practices, informal assessment, technological instruments, and communication than they did before attending the professional development. The quantitative findings indicated the attendance in the professional development activities was significantly correlated with the quality of the in-class PBL implementation in 2010. In addition, qualitative results showed that the teachers viewed STEM PBL pedagogy as a way to promote student interest in mathematics.

The second article investigated the effect of STEM PBL on Hispanic and at-risk students' mathematics achievements. The participants were students from STEM PBL high schools and non-STEM PBL schools in the same region. In STEM PBL schools, students can communicate and collaborate with peers and teachers in small groups while exploring a project (Chen, Lam & Chan, 2008). STEM PBL engages students in solving problems within a project either individually or in a group. They explore strategies and apply content knowledge to real-world problems (Barron et al., 1998). Latent growth modeling was used to analyze the repeated measures across years. The results indicated STEM PBL instruction positively influenced Hispanic student achievement in mathematics but not at-risk students.

The last study investigated whether participating in STEM PBL activities influenced students with varied performance levels and to what extent student individual factors influenced their mathematics achievement. The participants were high school students from three different high schools. The effects of STEM PBL have been reported with several studies supporting the positive impact on student content knowledge (Barron et al., 1998; Boaler, 1997; Liu & Hsiao, 2002). The application of hands-on activities and field-based contexts of STEM PBL were the primary factors that resulted in positive effects on student content knowledge (Kaldi, Filippatou, & Govaris, 2011). The findings of the study showed statistically significantly higher growth rates on mathematics than middle- and high-performing students over a period of 3 years.

Middle Schools

Olivarez (2012) investigated the impact of the STEM program on academic achievement. The participants were eighth graders; 73 were students in a STEM academic program, while 103 were students in a non-STEM academic program. The conclusion was that participation in a STEM academic program where teachers use PBL, collaborative learning, and hands-on strategies positively impacted eighth-grade student academic achievement in mathematics, science, and reading. The study was conducted in an area predominantly populated by Hispanics. The disparity between the academic achievement of Hispanic and non-Hispanic White students has been documented. This was linked to a significant percentage of Hispanic parents not completing high school or pursuing further education. Other factors included lack of parental involvement, low parental expectations, and lack of motivation on the student's part. Hispanic students who graduate from high school are less qualified to be admitted to a 4-year college compared to their White counterparts. They also have low test scores across subjects and are less likely to take advanced coursework (Reigle-Crumb & Callahan, 2009).

Elementary Schools

Barth (2013) conducted a study on the effects of science-engineering integration on student learning, student attitudes, and student interest in science in elementary school. Integration of curriculum is being researched at multiple levels within education. Literature in educational research contains some examples of STEM integration within K-12 education, but more studies within elementary levels are needed (Cantrell, Pekcan, & Itani, 2006). Several arguments have been made in support of including curriculum integration within K-12. One argument is that curriculum integration is practical as it follows patterns of how disciplines are integrated outside of an educational setting. Mason (1996) viewed integrated curriculum to prepare students for the world in which they live. Hurd (1991) added that the disciplines of science and technology are currently merging into an integrated system making integrating the discipline in schools vital in preparing students for the future. This research suggests that educators who use the pedagogy of integration may be able to meet the needs and help students achieve greater levels of learning (Cunningham, Lachapelle, & Hertel, 2012).

McClain (2015) conducted a study to determine if there was a significant difference between the academic achievement of underrepresented minority students who were exposed to STEM education and minority students who were not exposed to STEM education. The information for the study was from a criterion-referenced competency test where comparison of scores of students with STEM education and non-STEM education was done. The study revealed mixed results of the relationship between STEM and non-STEM education student test scores. This means that STEM education has the potential to improve student achievement on standardized assessments. Performance within education is varied across race/ethnicity and gender. NCES explored the achievement gaps between students from the different subgroups using NAEP to shed light on the patterns and identify factors that might underlie such differences. Black and Hispanic students have shown a gain in the percentage of students scoring at or above proficient between 2009 and 2013. The gains have done little to narrow the achievement gap between them and their White counterparts.

Theoretical Framework

Bruner's (1966) discovery learning theory. Bruner (1966) was one of the founders of constructivist theory, and the discovery learning theory was influenced by Piaget's ideas about cognitive development in children. The theoretical framework, according to Bruner (1966), is based on the theme that the learners construct new concepts based on existing knowledge. Constructivism is a broad conceptual framework with several perspectives; Bruner's (1966) theory being one of them. Bruner's (1966) theory emphasizes the importance of categorization in learning. The key concept in learning is interpreting information and experiences by similarities and differences (Bruner, 1961). Bruner's (1961) early works dating back to the 1940s focused on the impact of needs, motivation, and expectation and the influence on perception which are referred to as mental sets.

Bruner (1966) explored the role of strategies in the process of human categorization and introduced the view that children are active problem solvers capable of exploring the surroundings around them. Bruner's (1966) theory early work led to the emergence of four key themes:

1. The role of structure in learning and the need to be made central in teaching.
2. A spiral curriculum where ideas are revisited and build upon to the level of understanding and mastery.
3. Intuitive and analytical thinking should be encouraged and rewarded.
4. The motivation for learning where interest in the subject matter is built and becomes a stimulus for learning.

Bruner's (1966) theory was then influenced by Vygotsky's and turned away from the intrapersonal focus for learning to a social and political view of learning. Bruner (1966) placed more emphasis on the social influences on development and identified three stages of cognitive representation which are integrated. Bruner (1963) believed that learning occurs through three stages and should begin with direct manipulation of objects; then the learner should be encouraged to construct visual representation; and finally, the learner understands the symbols associated with what they represent (McLeod, 2008). The three stages are as follows:

Enactive stage 0-1 year (action-based). This is the first stage which involves encoding and storage of information. Knowledge is represented through actions and involves manipulation of objects.

Iconic stage 1-7 years (image-based). In this stage, learning is achieved through using models and pictures. Learning involves representation of external objects usually in the form of a mental image or icon.

Symbolic stage 7 and up (language-based). The last stage, learners, develop the capacity to think in abstract terms. Information is stored in the form of code or a symbol such as a language.

Discovery learning implies a learner constructs knowledge as opposed to being told what to do. The role of the teacher should be a facilitator who develops lessons but does not organize them for the learner (Bruner, 1961). Types of discovery learning used in schools are experiments, exploration, web quests, simulation-based learning, inquiry-based learning, and PBL. The educational goals of discovery learning include a deep understanding, developing meta-cognitive skills, and encouraging a high level of student engagement (Saab, van Joolingen, & van Hout-Wolters, 2005). Similar constructivist learning theories were developed by John Dewey and Lev Vygotsky; both suggested that discovery learning encourages students to become active participants in the learning process (Saab et al., 2005).

Discovery learning has three main characteristics: exploration and problem solving, student-centered activities, and scaffolding new information into students' existing knowledge (Bicknell-Holmes & Hoffman, 2000). This is different from the traditional learning models with five notable differences. Castronova (2002) identified five characteristics of discovery learning which differentiate it from the traditional models.

1. Learning is active with hands-on and problem-solving activities instead of knowledge transfer.
2. Discovery learning emphasizes the process instead of the end product.
3. Lessons learned from failure encourage mastery and application.
4. Feedback, collaboration, and discussion are an essential part of the learning process.

5. Discovery learning promotes individual interests through the satisfaction of human curiosity.

The discovery learning model has advantages, such as it encourages motivation, active involvement, and creativity; can be adjusted to the learner's pace; promotes autonomy and independence; and ensures higher levels of retention (Bruner, 1961).

Barrows's (1986) PBL theory. The origin of PBL can be traced back to the progressive movement. PBL shares Dewey's belief that teachers should teach by appealing to student natural instincts to investigate and create (Barrows, 1986). Barrows (1986), a physician and medical educator, developed methods of instructing physicians to build capabilities for reflection outside of school. This led to Barrows's (1986) first educational objective for PBL which stated, "the medical students we educate must acquire basic science knowledge that is better retained, retrieved, and later used in the clinical context" (p. 5).

PBL is identified as a constructivist learning environment with the instructional principles described in a constructivist framework (Savery & Duffy, 1995). The instructional principles are based on the assumption that learners are constructors of knowledge gained. The learning environment should be developed to encourage active participation of learners. Schmidt (1983) summarized PBL in three essential principles: activation of prior learning using stated problem, students recall what has been learned better in the context in which the knowledge will be used, and learning enhances subsequent retrieval.

Implications of Bruner's (1966) Theory and Barrows's (1986) Theory on Education

Bruner (1971) felt the goal of education should be intellectual development and not rote memorization of facts. Bruner (1973) felt the purpose of education is not to impart knowledge but facilitate a learner's thinking and problem-solving skills to be transferred to different situations. Students are active learners with the ability to construct knowledge and the capability of understanding complex information. This is supported by the concept of the "spiral curriculum" which is one of Bruner's (1961) key themes. The curriculum involved information structured so that complex ideas are taught first at a simplified level. The ideas are then revisited later at a more complex level. This means that concepts are taught at levels gradually increasing difficulty leading to learners being able to solve problems independently (Bruner, 1961).

Barrows (1996) first used PBL at McMaster University in the mid-1960s and has since led to more than 60 medical schools using PBL. This has also been used in high schools, middle schools, and elementary schools. In education, PBL has been adopted by K-12 schools to raise student achievement. PBL offers teachers a structured method to utilize in building thinking and problem-solving skills of students leading to mastery of the subject matter (Delisle, 1997). PBL transfers the active role in the classroom to students through problems that require finding information, thinking through the situation, and solving the problem (Delisle, 1997). Being able to understand how to use discovery learning and PBL in the classroom, educators will be able to increase student motivation, involvement, and achievement levels.

Summary

A review of the literature reveals different events and publications that brought attention to the current situation of education in the U.S. The events included the mathematics wars and the launching of the Sputnik by the Russians. This was viewed as a major humiliation to Americans and prompted attention to the low quality of mathematics and science in the U.S. These events ultimately led to the development of

STEM education. Several publications and policies aimed to improve America's competitiveness in the world are included in the review. Important aspects of the STEM education are discussed in the review and include occupation careers related to STEM programs, instruction strategies for STEM programs, a detailed definition of STEM programs, definition of traditional schools, and research influencing the STEM program.

Five studies were reviewed: two for elementary level, one for middle school level, and two for high school. The studies for elementary level examined the effect of STEM education on mathematics achievement of fourth-grade minority students and the effects of integrating science and engineering content in elementary level. The middle school study examined the impact of STEM programs on the academic achievement of eighth-grade students. This study was the only one that was close to the proposed study. The difference was that it did not utilize standardized tests as an indicator and was for middle school level. For the two high school studies, one examined the STEM PBL teacher professional development on student mathematics in high school; and the second one the influences of mathematics self-efficacy, identity, interest, and parental involvement on STEM achievement in algebra for female high school students. There is a gap of research on the achievement of high school STEM students using standardized tests as an indicator. The study was the first to examine how effective the program is using state EOC examination and standardized test ACT. The graduation rate for the two programs were analyzed and documented in this study.

Chapter 3 describes the design that was used to conduct the study. A brief history of the research design and a study design framework are provided. The chapter addresses the research questions, participant selection, data sources and analysis, and limitations of the method.

Chapter 3: Research Design and Methodology

Introduction

This chapter describes the research design and methodology used to conduct the study that compared the STEM program to the traditional program in a suburban high school. A mixed-method research approach was used to provide a comprehensive understanding of the impact of the STEM program on student achievement. The EOC state assessment, ACT, and the graduation rate of the high school seniors were used as the academic achievement indicator. A convergent parallel mixed-methods approach was used as the design for this study. This is a form of mixed-methods design in which the researcher merges quantitative and qualitative data to provide a comprehensive analysis of the research problem (Creswell, 2014). Different terms are used for this type of approach including quantitative and qualitative methods, integrating, and multimethod and mixed methodology. It was until recently that the term mixed method was used for this approach (Tashakkori & Teddlie, 1998).

Purpose of the Study

The goal of this study was to examine the impact of the STEM program on the academic achievement of high school students as compared to the traditional program. The graduation rate of the high school seniors, EOC state assessment, and the standardized test ACT were used as the academic achievement indicator. The Department of Accountability Service Division of Public Schools of North Carolina has the task of promoting the academic achievement of North Carolina public school students. This helps stakeholders understand and compare student achievement against state and national standards by collecting and analyzing data (North Carolina Department of Public Instruction [NCDPI], 2016). The high school where the study was conducted was the only magnet high school in the school district that offered the STEM program.

Research Questions

The questions used to guide the study were as follows.

1. To what extent is there a statistically significant difference in the achievement of students who are in STEM program as opposed to students in the traditional program?
2. To what extent is there a statistically significant difference in the graduation rate of students who completed the STEM program as opposed to students in the traditional program?
3. To what extent is there an association between the professional development activities of STEM faculty and student achievement?
4. What perception do teachers have regarding the overall impact of the STEM program?

Null Hypothesis

The null hypotheses for the first three research questions were

1. There is no statistically significant difference in the achievement of students who are in the STEM program as opposed to students in the traditional program.
2. There is no statistically significant difference in the graduation rate of students who completed the STEM program as opposed to students in the traditional program.
3. There is no association in student achievement based on the professional development activities in which STEM faculty participate.

Research Methods

Mixed-method research is defined “as an approach to inquiry that combines both qualitative and quantitative form of research” (Creswell, 2014, p. 4). The approach involves collecting, analyzing, and integrating quantitative and qualitative research in a single study. Using the mixed-method approach made it possible to have a variation in data collected which led to greater validity and eliminated preexisting assumptions that the researcher might have had. The method also answered questions from several perspectives which could not have been the case if one methodology was used.

The history of the mixed-method approach dates back to the 1980s. “The emergence of the mixed method as a third methodological movement in social and behavioral sciences began during the 1980’s” (Tashakkori & Teddlie, 1998, p. 697). In the 1980s, the term multimethodology was used to describe the approach (Brewer & Hunter, 1989). The following is a brief history of the mixed method history before the 1980s.

1. 1959: Psychologists Campbell and Fiske applied correlational analysis on multiple traits gathered by different methods to demonstrate the independence of the methods and their characteristics.
2. 1973: S.D. Sieber combined the qualitative and quantitative data by integrating fieldworks and survey methods.
3. 1979: Denzin and Jick expanded mixed method literature by emphasizing the need of triangulation of data sources that mixed method provided and incorporate the use of qualitative methods within a mixed method.
4. 1989-2003: Tashakkori and Teddlie (1998) expanded procedures for mixed methods which led to the works of Creswell.

Study Design Framework

To be able to compare the STEM program and the traditional program, information on entrance requirements, student demographics, performance on standardized tests (end-of-grade [EOG], EOC, ACT) and graduation rates was used. Figure 3 shows the study design that was used to illustrate the interaction of the qualitative and quantitative components of the study.

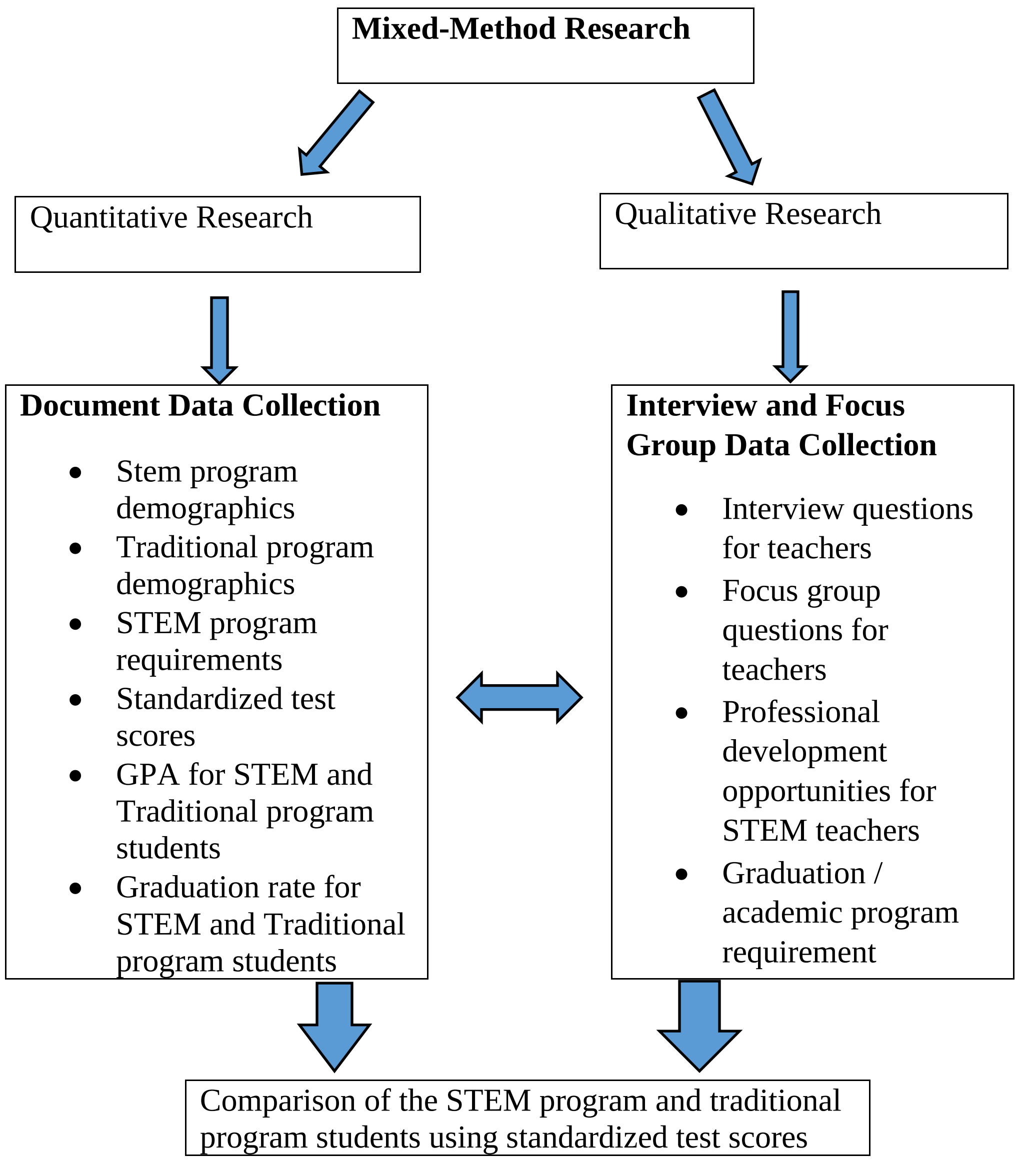


Figure 3. Study Design Framework.

Participants and Site Selection

The selection of the site and the participants was completed using a concurrent mixed-method approach sampling (Creswell, 2014). Concurrent mixed-method design allows researchers to triangulate the results from the separate quantitative and qualitative components of the research making it possible for one to cross-validate within a single study (Creswell, Plano Clark, Gutmann, & Hanson, 2003). In concurrent mixed-method sampling, probability sampling techniques were used to generate data for the quantitative phase, and purposive sampling techniques were used to generate data for the qualitative phase. The sampling procedures for these phases were conducted independently.

The site for the study was a high school located in a suburban neighborhood in North Carolina already implementing the STEM program. The suburban neighborhood is usually located outside a city with a population not quite as dense as the city. The school is the only magnet school in the school district offering the STEM program. The study was delimited to STEM program students and traditional program students who enrolled in the 2011-2012 school year.

Description of the Site

The school where the study was conducted is in a school district that has been educating students for nearly 100 years. The current population of students is 30,000 in 39 schools. The school district has seven high schools and four non-traditional high schools. The school selected is the only magnet STEM high school with mixed student demographics (school district website).

The selected school has a student population of 1,712 students: 351 in the STEM program and 1,361 in the traditional program. The student population at the site is diverse with a racial makeup of 55.7% White, 21.9% African-American, 15.7% Hispanic, and 6.7% other ethnicities. The school has 50% economically disadvantaged students who receive free or discounted meals. The school has 83 certified teachers, 24 support staff, four administrators, four counselors, one graduation coach, and one social worker. Also, the school has one full-time registered nurse. Eighty percent of the teachers are highly qualified teachers with 12 being National Board Certified teachers. The mission of the school is to "graduate students who are successful, responsible and contributing citizens in a rapidly changing world by working with the community to provide superior instruction and a quality learning environment" (school website).

STEM Program Students

The STEM program was introduced to the school site during the 2010-2011 academic year. The first group of STEM students graduated from a magnet middle school in the school district, and the research site was chosen as the STEM magnet high school for the school district. To continue eligibility in the middle school STEM program, the student must maintain level 3 and above on the EOG exams. This has been the requirement for the past 5 years until last school year when it changed to level 2. The students automatically progress to high school if they score a level 3, 4, or 5 on the reading and mathematics EOGs in seventh and eighth grade. Students from other schools must meet the following criteria to be admitted into the STEM program at the school.

1. Successfully complete Math 1 prior to entering ninth grade.
2. Score a level 3, 4 or 5 on the reading and math EOGs in seventh and eighth grades to meet local promotion requirements.
3. Score 75% or higher on a nationally normed test for students not enrolled in the district.

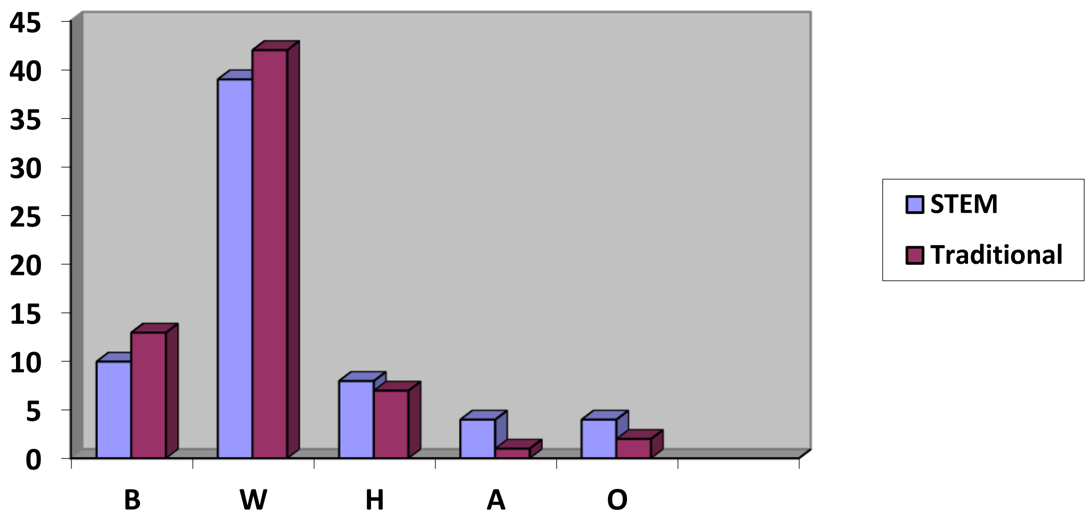
To continue in the STEM program, students must meet an overall grade average of 80%

on the final average of the eight courses taken each year and pass all courses taken. In addition, students must meet the behavior requirement of not having three or more in-school or out-of-school suspensions and attendance standards of eight or fewer absences per semester. Over the course of the year, students who are in danger of not maintaining an overall average of 80% or are failing a course receive academic interventions such as student and/or parent conference, after-school tutoring with a peer or teacher, and mentoring (school website). The participants for this study consisted of 65 STEM students who joined the high school STEM program during the 2011-2012 school year. The selection of the participants was purposeful sampling due to the limited number of STEM students enrolled in the school.

Traditional Program Students

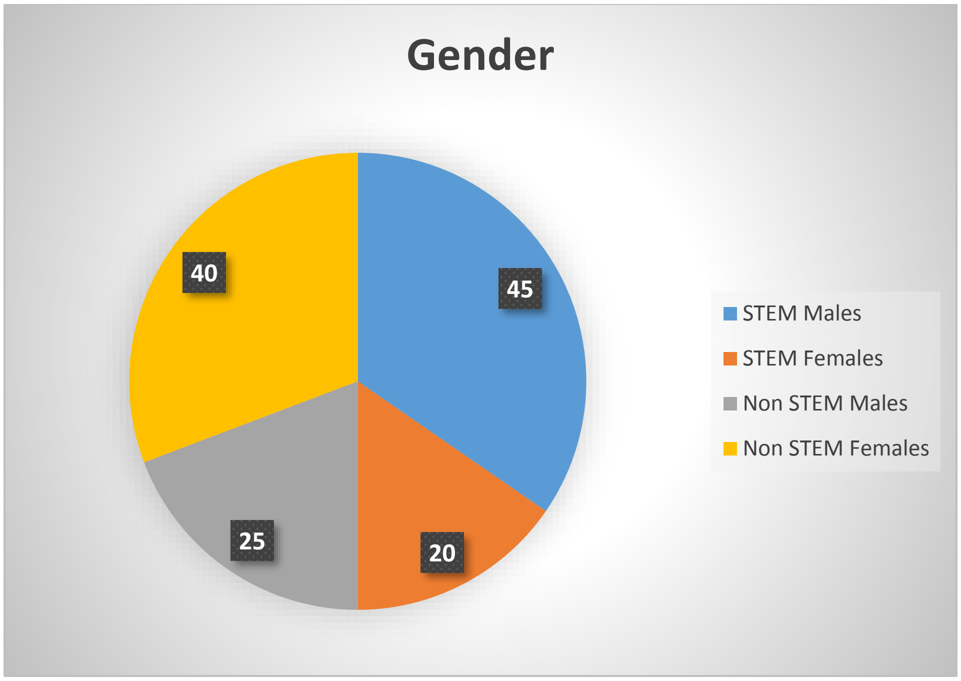
The traditional program at the site school has students enrolled from the assigned neighborhood feeder middle school. Students are required to take eight courses per academic school year. The courses range from regular courses, electives, honor courses, and Advanced Placement (AP) courses. Since the STEM students take honor and AP courses, the participant students from the traditional program were the ones who enrolled in honor and AP courses. The number of traditional program students included in the study was approximately 65. Since there are more traditional program students, the criteria for selecting students to participate were those who had a 3 or above in English language arts and mathematics EOG examinations in middle school. In addition, the traditional program students selected were the ones who were enrolled in honors and AP courses. Since the number of students in the traditional program who met the above criteria was more than 65, random sampling was used to come up with the 65 participants. Demographic information for the students by ethnicity and gender is illustrated below using Figures 4 and 5.

Ethnicity



	STEM	Traditional
B – Black or African-American	10	13
W – White	39	42
H – Hispanic or Latino	8	7
A – Asians	4	1
O – Others	4	2

Figure 4. Student Demographic Information by Ethnicity.



STEM Males	45
STEM Females	20
Traditional Males	25
Traditional Females	40

Figure 5. Student Demographic Information by Gender.

STEM and Non-STEM Teachers

The main participants for this study were STEM teachers and teachers who teach both STEM courses and traditional courses. The groups of teachers were selected because they have the responsibility of implementing the STEM program in the school. Interviews, focus groups, and questionnaire were utilized to get perceptual data from the teachers. In this study, purposeful sampling was used to select the non-STEM teachers for in-depth interviews, and heterogeneous sampling was used for focus group interviews (Patton, 2002).

Table 2

Teacher Profiles–STEM Teachers

Name	Course	Grade	Years of Experience
Teacher 1	Technology Design & Robotics	10-12	7
Teacher 2	Design & Technology	9-10	9
Teacher 3	Technology & Design	9-10	2
Teacher 4	STEM World & American History	9-11	5
Teacher 5	STEM English I & II	9-10	23
Teacher 6	Engineering Design & Robotics	10-12	3

Table 3

Teacher Profiles–STEM and Traditional Courses

Name	Course	Grade	Years of Experience
Teacher 1	STEM & Regular Civics & Econ.	10-11	2
Teacher 2	STEM & Regular Math II & III	10-11	5
Teacher 3	STEM & Regular Physics	9-12	7
Teacher 4	STEM & Regular Calculus	10-12	5
Teacher 5	STEM & Regular Chemistry	10-12	4
Teacher 6	STEM English II & Regular AP Lit.	10-12	10
Teacher 7	STEM English IV & Regular Eng. III	11-12	2
Teacher 8	STEM Pre-Calculus & Regular Math III	10-11	2
Teacher 9	STEM Physics & Physical Science	9-11	1
Teacher 10	STEM & Regular Health & PE	9-10	8
Teacher 11	STEM & Regular Biology/ AP Biology	10-12	29
Teacher 12	STEM Pre-Calculus & Regular Math I	9-11	1

Table 4 summarizes the profiles of the participating teachers by gender, ethnicity, and number of years of experience.

Table 4

Profile of Teachers

	STEM Teachers (n=6)		Teachers who teach STEM & Traditional courses (n=12)	
Demographic Characteristics	F	%	F	%
Gender				
Male	3	50%	6	50%
Female	3	50%	6	50%
Ethnicity				
Hispanic	0	0%	1	11%
Non-Hispanic	6	100%	11	89%
Years of Experience	M	SD	M	SD
	9.33	10.19	12.64	9.12

The teachers who teach STEM and traditional courses (*M* = 12.64, SD = 9.12) had more years of teaching experience than the teachers who teach STEM courses alone (*M* = 9.33, SD = 10.19). Both groups had equal numbers of male and female teachers. The teachers who teach STEM and traditional courses (n = 12) were more in number than the teachers who teach STEM courses alone (n = 6). All teachers who teach STEM courses were non-Hispanic, while the teachers who teach STEM and traditional courses had non-Hispanics being the majority (89%, n = 12) and Hispanic (11%, n = 12).

Role of the Researcher

The researcher is a teacher at the site and has taught in the school for 4 years. Before that, the researcher worked in the same school district in a different school for 6 years. The researcher is a trained Family and Consumer Science teacher teaching the Career Technical Education (CTE) courses, Fundamental of Foods, and Foods II Enterprise. The researcher interacts with both the STEM and traditional teachers in the school and has taught some of the students who were participants in the study. The researcher's role as a teacher in the site did not impact the findings of the study.

Data Sources and Collection

For the purpose of the study, scores for the standardized tests ACT and EOC examination were obtained from the school. Demographic data on selected participating students were collected. This included information on their age, gender, and ethnicity. This information was important to differentiate between different subgroups and offer an insight that might have been missed by just looking at the aggregate data. Since this was a mixed-method research, the section was divided into two subsections: quantitative and qualitative phase.

Quantitative Phase

The survey is one method that the researcher used in this phase. Survey data generalizes from a sample to a population and allows quick turnaround (Creswell, 2014). A teacher perception survey (Appendix D) was issued to STEM teachers, traditional teachers, and teachers who teach both STEM courses and traditional courses to get their perceptions of the STEM program and different instructional methods used. The questionnaire was available in both electronic and paper formats. The survey was piloted by eight teachers from the CTE from the site school. The researcher issued paper copies of the survey and asked the participants to comment on the survey using the following headings: clarity of questions and response options, length of time to complete the survey, and any inconsistencies or unexpected answers (Suskie, 1996).

The researcher reviewed the test responses based on the feedback received from the pilot and made necessary changes to the survey. Piloting is important to ensure the content validity and to improve features of the survey like format, questions, and scales (Creswell, 2014). Random sampling was not used for the STEM teachers and teachers who teach both STEM courses and traditional courses. Instead, cluster sampling was used where the researcher identified the group and sampled within the group (Creswell, 2014). Random sampling was used for the traditional group for the interview and focus group.

Standardized Test Scores

Standardized test scores for ACT and EOC examination scores for the two groups were used. The first set of scores were the EOC scores in Math I, English II, and Biology for the participating students. The second set of scores were the ACT scores. Last, grade point averages (GPA) for all the participants at the time of their graduation (2016) were used to compare the achievement levels of the STEM and traditional students.

Qualitative Phase

The qualitative phase involved a variety of methods to collect data. Qualitative research requires robust data collection techniques and documentation of the research procedures (Bowen, 2009). Patton (2002) provided three reasons to gather qualitative data: When an educational program is based on humanistic values, qualitative data allows personal contact; qualitative methods are acceptable when no useful, practical, valid, or reliable quantitative measure can be found; and qualitative data can be used to add depth to quantitative measures. This study qualified for all the three reasons. The methods the researcher used included interviews with individuals and a focus group, information from the school website, and document review. Techniques the researcher used to collect data in this phase were audio recordings, memos, journals, and authentic documentation.

Questions were created that were used for the interviews and focus groups of STEM teachers and teachers who teach a combination of STEM and traditional courses. The interviews were conducted face to face and audio recorded for clarity. Transcripts were made from each interview which provided written text analysis. To ensure anonymity, pseudonyms were assigned to each participant. There were two focus groups, one for teachers who teach STEM courses alone and one for teachers who teach a combination of STEM and traditional courses. The focus group meetings were recorded, and transcripts of the recordings were made.

Interviews and Focus Groups

All interviews were conducted during school hours during teacher planning periods and the additional remediation and eating block that the school has. Two focus groups were conducted, one with the teachers who teach STEM courses and the second one for teachers teaching the STEM and traditional courses. Two individual interviews were done, one for the STEM department head and the second one for the World Languages department head to represent the traditional courses. Since there are several departments for the traditional courses, the second department head was randomly selected. The focus groups began with a brief introduction where participants introduced themselves, areas of certification, years of teaching experience, and the grades they currently teach. All participants were to complete a consent form before the focus group and the interviews. The focus groups took approximately 45 minutes, while the individual interviews were between 15 to 20 minutes. A one-on-one, semi-structured interview protocol was used.

A focus group is a technique involving the use of in-depth group interviews in which participants are selected because they are a purposeful, although not necessarily representative, sampling of a specific population (Thomas, MacMillan, McColl, Hale, & Bond, 1995). The primary purpose of the focus group research was to draw upon respondent attitudes, feelings, beliefs, experiences, and reactions in a way which would not be feasible using other methods (Creswell, 2014). The participants for the focus groups were teachers who teach STEM courses and teachers who teach a combination of STEM and traditional courses. Focus group prompts (Appendix E) were written in advance and used during both focus groups. The interviews were recorded on a smartphone and transcribed before being analyzed. Appendix F shows the individual interview prompts.

Document Analysis

Document analysis is a systematic procedure for reviewing or evaluating documents both printed and electronic. It requires that the data be examined and interpreted to elicit meaning, gain understanding, and develop empirical knowledge (Corbin & Strauss, 2008). Document analysis is used in combination with other qualitative research methods as a means of triangulation. Sources of document review involve a variety of sources like documents, reports, data files, and other written artifacts. The first document that was reviewed was the North Carolina report card for the 2015-2016 school year that showed the different achievement indicators used to grade the performance of the school site. The second document was the report from the Accountability Service Division which had the graduation rate broken down by different subgroups.

Table 5

Data Analysis Overview

Research Question	Data Sources	Data Analysis
To what extend is there a statistically difference in the achievement of students who are in STEM program as opposed to students in the traditional program?	School Report Card Standardized Test Scores	Descriptive Descriptive
To what extend is there a statistically difference in the graduation rate of students who completed STEM program as opposed to the traditional program?	NC Report Card Graduate Point Average (GPA)	Descriptive Descriptive
To what extend do professional development activities that faculty participates in impact student achievement?	Focus Group Interviews	Transcript Transcript
What perception do teachers have regarding the overall impact of the STEM program on STEM students?	Questionnaire Interviews	Descriptive Transcript

Data Analysis Procedures

The analysis of quantitative data involves summarizing mass data that have been collected and presenting the results in a way that communicates the most important findings (Cramer, 2003). Analysis of quantitative research involves the analysis of any of the following: frequencies of variables, differences between variables, and a statistical test designed to estimate the significance of the results and the probability that they did not occur by chance (Cramer, 2003). Data that were obtained from EOC and ACT scores were downloaded into the Statistical Packages for the Social Sciences (SPSS). Descriptive statistics were used to summarize and organize the data. The tests that were used for the study were the Independent Sample *t* Test, the Chi-Square Test of Independence and Pearson R Correlation.

The Independent Sample *t* Test was used to assess whether the means of the two groups, STEM and traditional program, on the standardized tests are statistically different from each other. "The t-Test is used to compare the means of two independent samples on a given variable" (Urdan, 2010, p. 93). The researcher looked at the standardized tests for the STEM group and the traditional group which made the test the right one used to compare the groups. In this study, the STEM and traditional program are the independent variables, while the student achievement as indicated by the standardized tests is the dependent variable. Independent variable is the variable that comes first and influences or predicts the dependent variable, while the second variable that is affected or predicted by the independent variable is the dependent variable (McMillan, 2008).

The Chi-Square Test of Independence was applicable for the study as data from two or more categorical variables were used (Urdan, 2010). One example of categorical data that were collected and analyzed is the gender that is divided into male and female. The test enabled the researcher to know if the number of the students who fell into the categories were in proportions equal to what would be expected by chance. For example, the researcher wanted to know whether the representation of males and females depended on their programs (STEM and traditional) or if the representation of male and females was what would be expected independent of the programs.

A Pearson R Correlation was run to determine associations between teacher perceptions and student achievement. The Pearson R Correlation is a measure of the strength of a linear association between two variables (Laerd Statistics, 2016). It is the best method because it provides information about the magnitude of the association as well as the direction of the relationship (Agresti & Franklin, 2014). The three areas that were used for the teacher perception survey were how prepared students are in the classroom, engagement level of the students, and how motivated the students are in the classroom.

Data obtained using interviews focus groups and document analysis were analyzed using content analysis. The content was analyzed using two different levels: (a) the manifest level which is a descriptive account of the data just as the participants said it; and (b) the latent level of analysis which is a more interpretive analysis that is concerned with the response as well as what may have been inferred or implied (Harding, 2013). Content analysis involves coding and classifying data with the aim of making sense of the data collected and to highlight the important findings.

The steps used in analyzing the qualitative data included four steps as follows: raw data management which involved data cleaning; data reduction where there was chunking and coding of the data; data interpretation where additional coding and clustering was done; and data representation which involved making sense of the data for others to understand (Strauss & Corbin, 2004). The coding of the qualitative data involved open coding where the data were broken down, compared, and categorized. This was followed by axial coding where connections between the categories were made.

Validity and Reliability

Creswell (2014) defined validity as the ability to draw meaningful and useful inferences from the scores on instruments. Validity is the degree to which a research study measures what it intends to measure. The two types internal and external validity are important in any research. Internal validity refers to the validity of the measurement and the test itself, whereas external validity refers to the ability to generalize findings to the target population (Hardesty & Bearden, 2004). Threats to internal validity were minimized in the selection process of the participants. The researcher reduced the difference between the participants by ensuring that the criteria for selection for both groups (STEM and traditional students) were the same. Since the STEM students have an entrance requirement of scoring 3 or above in eighth-grade EOG exams, the same criteria were used for traditional students. Also, STEM students only take core honor courses which limited the participants from the traditional students to those who were enrolled in honor courses. Random sampling was used for the traditional students due to their large number compared to STEM students. This was done after identifying the ones who met the criteria.

Reliability is the degree to which the assessment tool produces stable and consistent results (Creswell, 2014). The researcher used test-retest reliability to measure the reliability of the teacher survey. The survey was administered twice, and the scores were correlated to evaluate the survey for stability over time. Creswell (2014) recommended the use of multiple approaches to enhance the researcher's ability to assess the accuracy of findings as well as convincing the readers of the authenticity of the results. Several sources of validity evidence can be used to measure the validity of different types of tests. They include test content, internal structure, relations to other variables, response processes, and consequences (McMillan, 2008). The validity of the standardized tests can be measured using content validity, criterion-related validity, and construct validity (McMillan, 2008). Criterion-related validity refers to the fact that a student has shown mastery of certain criteria or data that have been learned (McMillan, 2008). This leads to the ability of the standardized test being able to predict how well the student will do in college. The validity of the standardized tests is guaranteed as experts examine the tests before they are ready for administration (McMillan, 2008). The ACT undergoes several revisions to ensure validity and reliability to prevent testing bias

(CollegeBoard, 2014). The use of experts guarantees the reliability of standardized tests as the tests must meet the psychometric standards of reliability. The ACT is reliable, given that a student could take the test and get approximately the same result.

NCDPI (2016) has two important goals in administering the EOC examinations. The goals are

1. To achieve the most reliable and accurate picture of student achievement with minimal impact on instructional time.
2. Remove bias by using valid and reliable psychometric methods during the test development.

The two types of validity used for the EOC tests are content validity and concurrent validity (NCDPI, 2016). Content validity ensures items are carefully aligned to the content standards, while concurrent validity shows the correlation of student performance with other measures (NCDPI, 2016). To achieve this, NCDPI uses experts to have independent alignment studies of the assessments. The state of North Carolina uses the coefficient estimate reliability to measure the reliability of the tests. The standard for state assessments used for accountability purposes is a coefficient alpha of .85 or higher. The EOC tests exceed this value. Different methods were implemented to avoid validity threats to the study. The methods are explained briefly in the three subsections below.

Triangulation Method

Triangulation is a method that is used to verify the accuracy of the data collected (Creswell, 2014). It involves the use of multiple independent sources of data to validate data and the research by cross verifying the same information. The type of triangulation the researcher used is the concurrent triangulation design depicted by Figure 6 below. In concurrent triangulation design, data are collected using two phases and integrated during interpretation and analysis (Terrell, 2011). This included different quantitative and qualitative data. To have credible findings from interviews and focus groups, the researcher backed up observations by comments made by the participants. The two phases of data collection were used to prevent threats to internal validity.

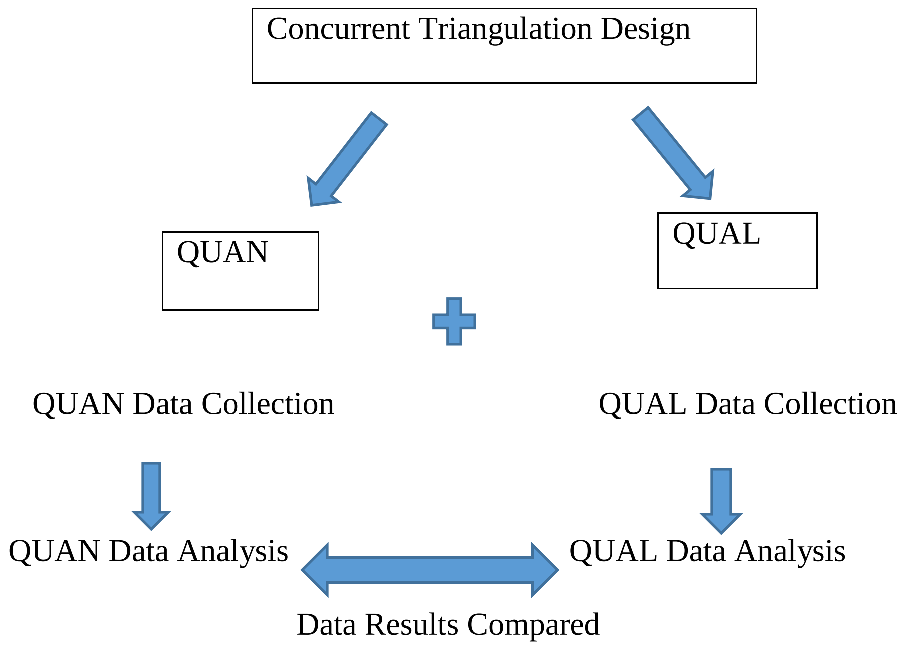


Figure 6. Visual for Concurrent Triangulation Design.

Member Checking

Member checking is a method used to check the accuracy of qualitative findings by having the participants go over the final report. This can be done by having a follow-up interview where the participants comment on the findings (Creswell, 2014). It is critical to use member checking in qualitative research studies because they involve interpretation allowing participants to validate the accuracy (Goldblatt, Karnieli-Miller, & Neumann, 2011). The greatest advantage of member checking is the researcher can verify the entirety and completeness of the findings which is a measurable tool of the accuracy of the findings (Goldblatt et al., 2011).

Member checking can be done during the interview process and at the end of the study to increase the credibility and validity of the study. During the interview/focus group, the researcher did member checking when opportunities for members arose by restating or summarizing information and then questioned the participants to determine accuracy. To confirm the credibility of the study and allow the participants to affirm that the summaries reflected their views, feelings, and experiences, member checking was also done at the end. The researcher shared the findings with the participants to allow them to critically analyze the findings.

Reactivity

Reactivity is a problem where participants may react to the fact of being part of a study, hence altering their behavior from what it would have normally been (Heppner, Wampold, & Kivlighan, 2008). Reactivity affects the validity of the research; the researcher informed the participants that all information gathered was strictly used for research and anonymity was used throughout the study.

Methodology Limitations

The limitations of the mixed-method design used for this study were data collection methods and sample size. Several methods were used to collect data but mainly focused on STEM teachers and traditional teachers. Since the standardized test data used were secondary data, the likelihood of the scores being reported to be inaccurate was a possibility. Also, the data were for students who graduated in 2016, making it impossible to administer a questionnaire to get their perceptions of the STEM program.

Compliance with Ethical Guidelines

All proper documentation was sent to the University's Institutional Review Board (IRB). Approval to conduct research was granted on the 21st of October 2016. The main function of the IRB is to support research ethics as described by the U.S. Department of Health and Human Services (2016). A verbal request to conduct the study was made by the researcher on April 25, 2015. A letter seeking permission was sent to the school principal on the 7th of July 2016 (Appendix G), and permission was granted (Appendix H). Confidentiality was assured to all participants as no names were associated with the data collected. Pseudonyms were used for all participants and recordings for the interviews, and the focus groups were transcribed immediately and destroyed upon completion. All participants were required to complete a consent form before the interview and focus group (Appendix I).

Summary

A mixed-method design was utilized for this study which allowed necessary data to be gathered and triangulated. The purpose of this study was to gain an in-depth understanding of the impact of the STEM program on student achievement. The EOC and ACT were used as the academic achievement indicators. The information was used to determine the graduation rate of STEM and traditional students. Data were collected concurrently through quantitative survey and document analysis for EOG, EOC, ACT, SAT scores, and GPA for the participating students. The qualitative data were gathered through individual interviews and focus groups. A matrix triangulating the data was constructed to validate the research.

Chapter 4, results and discussion, presents in sufficient detail the research findings and data analysis. The chapter has a brief introduction stating the problem briefly under investigation and the purpose of the study. Areas included in this chapter are a summary of the data collected and the statistical treatment of analysis used, restatement of each research question followed by the data analysis and the answers to the questions, discussion of each null hypothesis summarizing the results in nonstatistical terms, and an integration of the results with the literature reviewed in Chapter 2.

Chapter 4: Results

Introduction

This chapter describes the findings of the study in sufficient detail. The study compared the STEM program to the traditional program in a suburban high school. A mixed-method research approach was used to provide a comprehensive understanding of the impact of the STEM program on student achievement. The chapter has a brief introduction stating the problem under investigation and the purpose of the study. Areas included in this chapter are a summary of quantitative and qualitative data collected, the statistical treatment of analysis used, and restatement of each research question followed by the data analysis.

The research findings are reported in two major sections: qualitative and quantitative. The quantitative data included a teacher survey, STEM and traditional program demographic archival data, and student archival achievement data (state's EOC scores, ACT scores, and the GPAs of the participating students). The student data used were for students who joined the school during the 2011-2012 academic year. The qualitative data included the responses from the interviews and the focus groups. The responses and perceptions of participating teachers including classroom experiences are also be included in this chapter.

The purpose of this mixed-method research was to compare two graduation pathways in a southeastern high school. The study examined the impact of the STEM program on the academic achievement of high school students as compared to the traditional program. The graduation rate of the high school seniors, EOC state assessment and standardized test ACT, and the GPAs of the graduating students were used as the academic achievement indicators. The null hypothesis for the study was, "there is no statistical difference in the achievement level and graduation of students who are in the STEM program as opposed to students in the traditional program." The following questions guided the study.

1. To what extent is there a statistically significant difference in the achievement of students who are in the STEM program as opposed to students in the traditional program?
2. To what extent is there a statistically significant difference in the graduation rate of students who completed the STEM program as opposed to students in the traditional program?
3. To what extent is there an association between the professional development activities of STEM faculty and student achievement?
4. What perception do teachers have regarding the overall impact of the STEM program?

Data Analysis Strategy

The analysis of quantitative data was done using SPSS. Data that were obtained from EOC, ACT, and GPA scores were downloaded into SPSS. Descriptive statistics were used to summarize and organize the data. The tests that were used for the study were the Independent Sample *t* Test, the Chi-Square Test of Independence, and Pearson R Correlation. The Independent Sample *t* Test was used to assess whether the means of the two groups, STEM and traditional programs, on the standardized tests were statistically different from each other. The Chi-Square Test of Independence was used to test whether the representation of males and females depended on their programs (STEM and traditional), or if the representation of male and females was what would be expected independent of the programs. The Pearson R Correlation Coefficient was run to determine associations between teacher perceptions and student achievement.

Data obtained using interviews and focus groups were analyzed using content analysis. This involved coding and classifying data with the aim of making sense of the data collected and to highlight the significant findings. The steps used in analyzing the qualitative data included raw data management which involved data cleaning; data reduction where there was chunking and coding of the data; data interpretation where additional coding and clustering was done; and data representation which involved making sense of the data for others to understand (Strauss & Corbin, 2004). The coding of the qualitative data involved open coding where the data was broken down, compared, and categorized. This was followed by axial coding where connections between the categories were made.

Quantitative Data Finding

Quantitative data came from two different sources. The first source was from archival data such as the number of participants from the two programs; gender; ethnicity; age; GPA scores; ACT scores; and EOC scores from Biology, Math 1, and English II. The second source was a teacher satisfaction survey regarding the overall impact of the STEM program in general completed by both STEM and traditional teachers. The survey also contained information about the level of engagement of STEM students and the use of PBL as a method of instruction and the frequency of usage by the teachers.

Data were collected for different purposes from the 130 participating students. This included descriptive information about the age, gender, and race of participating students. This information was only included descriptively here and not used in this research. The information adds to the context and provides an opportunity for inclusion in future research. Table 6 shows the percentage of the participants by gender and ethnicity and the means of the age of the two groups.

Table 6

Profile of Subjects

Demographic Characteristics	STEM Students (n=65) F	%	Traditional Students (n=65) F	%
Gender				
Male	45	69%	25	38%
Female	20	31%	40	62%
Ethnicity				
Hispanic	8	12%	7	11%
Non-Hispanic	57	88%	58	89%
Age	M	SD	M	SD
	18.32	.07	18.23	.46

The students in the STEM program ranged in age from 18 to 20 years old, while students in the traditional program ranged in age from 17 to 19 years old. The traditional students (*M*=18.23, SD= .46) were younger than the STEM students (*M*= 18.32, SD .07). Both genders did not equally represent the programs. The STEM program had more males (69%, n = 65) than females (31%, n = 65), while the traditional program had more females (62%. N = 65) than males (38%, n = 65). The majority of the students in the STEM program were White (60%, n = 39), followed by Blacks (16%, n = 10); Hispanics (12%, n = 8); Asians (6%, n = 4); and others (6%, = 4). The traditional program had similar distribution with Whites being the majority (61%, n =42), followed by Blacks (19%, n = 13); Hispanics (16%, n = 7); Asians (1%, n = 1); and others (3%, n = 2). Since there were cells with an expected frequency of less than five, ethnicity was recorded into Hispanic and Non-Hispanic.

Research Question 1

The academic achievement indicators used to compare the STEM and the traditional program included scores on ACT, Math 1, English II, and Biology and the GPA at the time of graduation. The scores of all participating students were collected and analyzed. The independent *t* test was used to compare the means between the STEM and traditional programs in ACT, Math 1, English II, and Biology. There were no outliers in the data, as assessed by inspection of a boxplot. The scores for each program was normally distributed, as assessed by Shapiro-Wilk's test (p >.05). The descriptive statistics data are summarized below.

Table 7

Descriptive Statistics

	Program	N	Mean	Std. Deviation	Std. Error Mean
ACT	STEM	65	21.6923	4.3622	.54107
	Traditional	65	19.6769	4.34492	.53892
Math	STEM	65	3.1846	.88198	.10940
	Traditional	65	3.0154	.90988	.11286
Biology	STEM	65	4.2769	.83867	.10402
	Traditional	65	4.0000	.88388	.10963
English	STEM	65	3.6923	.96700	.11994
	Traditional	65	3.8615	.60922	.07556
GPA	STEM	65	3.1853	.43294	.05370
	Traditional	65	3.6464	.56621	.07023

There were 65 STEM and 65 traditional students. The STEM students had a higher mean score in ACT (*M* = 21.70, SD = 4.36), Math 1 (*M* = 3.18, SD = 0.88), and Biology (*M* = 4.28, SD = 0.84) than the traditional students whose mean scores were ACT (*M* = 19.70, SD = 0.54), Math 1 (*M* = 3.01, SD = 0.91), and Biology (*M* = 4.00, SD

= 0.88). The traditional students had a higher mean score in English (*M* = 3.86, SD = 0.61) and GPA (*M* = 3.65, SD = 0.57) than the STEM students whose mean scores were English (*M* = 3.69, SD = 0.97), and GPA (*M* = 3.19, SD = 0.43).

Table 8

Assumption of Homogeneity of Variances for the Scores

	Program	Variance	Sig
ACT	STEM	19.029	.971
	Traditional	18.878	
Math 1	STEM	.778	.727
	Traditional	.828	
Biology	STEM	.703	.721
	Traditional	.781	
English II	STEM	.935	.005
	Traditional	.371	

The assumption of homogeneity of variances was assessed by Levene's test. There was homogeneity of variances for ACT (*p* = .971), Math 1 (*p* = 0.73), and Biology (.721). The assumption of homogeneity was violated for English II scores (*p* = .005).

Table 9

Group Differences for the Scores

	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
			Lower	Upper
ACT	2.01538	0.76367	.50434	3.52643
Math 1	.16923	.15718	-.14177	.48023
Biology	.27692	.15113	-.02211	.57596
English II	-.16923	.14176	-.45023	-.11177

The group differences for the mean scores were higher for the STEM students in ACT 2.02, 95% CI [0.50 to 3.53], Math 1 0.17, 95% CI [-0.14 to 0.48], and Biology 0.28, 95% CI [-0.02 to 0.58] than the traditional students. The group differences for the mean scores were higher for the traditional students in English II -0.17, 95% CI [-0.45 to 0.11].

Table 10

Statistical Significance for the Scores

	t	df	Sig (2-tailed)
ACT	2.639128	0.09	
Math 1	1.077	128	.284
Biology	1.832	128	.069
English II	-1.194	107.891	.235

An independent *t* test was performed to compare the performance of the STEM and traditional students using the different academic achievement indicators. The analysis produced a nonsignificant value for ACT scores (t (128) = 2.639, $p < 0.09$); Math 1 (t (128) = 1.077), $p < 0.28$); Biology (t (128) = 1.832, $p < 0.069$); and English II (t (107.891) = -1.194, $p < 0.24$). An independent *t* test was not performed for the GPA scores, as inspection of archival documents (Appendices J and K) revealed both groups of participating students graduated resulting to a 100% graduation rate.

Chi-Square

The Chi-Square Test of Independence was done to determine whether there is an association between the programs and gender. The results are shown using Table 11 below.

Table 11

Gender and Program Type

	Value	df	Asymptotic Significance (2 Sided)	Exact Sig. (2 Sided)	Exact Sig. (1 Sided)
Pearson Chi-Square	12.381	1	.000		

A Chi-Square Test of Independence was conducted between the type of gender and STEM program. All expected cell frequencies were greater than five. There was a statistically significant association between gender type and STEM program, $\chi2(1) = 12.381$, $p < .001$. The Chi-Square Test of Independence was used to determine whether there is an association between the programs and gender. The test does not inform on the magnitude of the association. Cramer's V is a measure that does provide an estimate of the strength between variables, and the results are shown using Table 12 below.

Table 12

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	.309	.000
	Cramer's V	.309	.000
N of Valid Cases		130	

The association was moderately strong (Cohen, 1988), Cramer's V=.309.

Research Question 2

One of the achievement indicators used in this study was the graduation rate of the participating students. The information about the graduation rate came from two sources, the North Carolina Report Card and the Accountability Service Division of North Carolina Public School (Appendices J and K).

Document Review

Two documents (Appendices J and K) were inspected for the graduation rate. The North Carolina Report Card for 2015/2016 school year showed the different achievement indicators used to grade the performance of the school. The graduation rate was one of the indicators, and the school had a 93% graduation rate (Appendix J). The report from the Accountability Service Division had the graduation rate broken down by different subgroups. In all the subgroups, the graduation rate was above 90%, with the graduation rate for all students being 92.7% (Appendix K). All the participating students from the STEM and traditional programs graduated at a 100% graduation rate.

Research Question 3

The teacher perception survey contained three sections regarding the level of student engagement at the site school. Table 13 below shows the responses from the participating teachers.

Table 13

Level of Student Engagement Responses

	Number	Percentage
How prepared are the students when they come to your class daily?		
Extremely prepared	4	6.45%
Moderately prepared	45	72.58%
Slightly prepared	12	19.35%
Not prepared	1	1.61%
What is the level of engagement among your students?		
Extremely engaged	13	21.67%
Moderately engaged	44	73.33%
Slightly engaged	3	5.00%
Not engaged	0	0.00%
How motivated are students in your classroom?		
Extremely motivated	9	14.52%
Moderately motivated	38	61.29%
Slightly motivated	15	24.19%
Not motivated	0	0.00%

The teacher perception survey contained three sections regarding the level of student engagement at the site school; 98.38% of the teachers surveyed indicated that the students were prepared when they came to class, with 79.03% respondents who marked moderately and extremely prepared. The survey discovered 100% of the teachers surveyed indicated the students were slightly, moderately, and extremely engaged. The results were the same with student motivation; with 100% of the teachers selecting slightly, moderately, and extremely motivated. The most response was 61.29% who marked moderately motivated.

Pearson R Correlation

The Pearson R Correlation coefficient was run to determine associations between teacher perceptions and student achievement. The survey data were disaggregated for the participating STEM teachers and for teachers who teach both STEM and traditional courses. This was correlated with each of the three sections of the teacher perception survey. The results are displayed using Table 14 below.

Table 14

Pearson R Correlation between Teacher Perceptions and Student Achievement

	Program	N	Pearson Correlation	Sig (2-Tailed)
Preparedness	STEM	6	1.000	0.000
	STEM & Trad.	12	-1.000	0.000
Engagement	STEM	6	1.000	0.000
	STEM & Trad.	12	-0.967	0.000
Motivation	STEM	6	1.000	0.000
	STEM & Trad.	12	0.984	0.000

There was a very strong positive correlation between responses from STEM teachers and the three sections of the survey: preparedness (r = 1, p < .000, n = 6); engagement (r = 1, p < .000, n = 6); and motivation (r = 1, p <.000, n = 6). There was a negative correlation between responses from teachers who teach STEM and traditional courses and the three sections of the survey: preparedness (r = -1.000, p = .000, n = 12); engagement (r = -0.967, p = .000, n = 12); and motivation (r = -0.984, p = .000, n = 12).

Survey

Surveys were distributed to the teachers at the school site both electronically via email and in paper form placed in teacher mailboxes. Sixty-two teachers responded to the survey (Appendix L). The survey was used to determine student preparedness, engagement, and motivation in the classroom. The survey also determined how often teachers collaborated with each other, their satisfaction of the professional development offered by the school, and the use of PBL. The survey was completed by 62 teachers from the STEM and the traditional programs. The survey contained 10 questions and gathered general information about professional development, the level of student engagement, and teaching resources and strategies. Three questions under the level of student engagement have already been discussed using the Pearson R Correlation. The remaining seven questions are discussed below. The data collected attempted to answer Research Questions 3 and 4.

3. To what extent is there an association between the professional development activities of STEM faculty and student achievement?
4. What perception do teachers have regarding the overall impact of the STEM program?

The first question identified the number of teachers who teach either STEM courses, traditional courses, or a combination of STEM and traditional courses. The table below shows the number of responses and percentages from the participants.

Table 15

Teachers Responses by Course

Do you teach STEM courses, traditional courses, or STEM and traditional courses?

Courses	Number	Percentage
STEM Course	6	9.68%
Traditional Courses	44	70.97%
STEM & Traditional	12	19.35%

Professional Development

The teacher perception survey contained two sections regarding professional development at the site school. The responses about professional development from the participating teachers are included below.

Table 16

Professional Development Responses

	Number	Percentage
How often do you collaborate with the members of your Professional Learning Community (PLC) team?		
Not at all	2	3.23%
1-2 times a week	36	58.06%
3-4 times a week	12	19.35%
Every day of the week	12	19.35%
How much attention does the school give to your professional growth?		
A great deal	24	38.71%
Moderate	30	48.39%
A little	7	11.29%
None	1	1. 61%

The majority of the respondents indicated they collaborate at least once in a week: 96.77% of the respondents selected every day of the week, 3-4 times a week, and 1-2 times a week. Only 3.23% of the participants responded they do not collaborate at all in their PLCs. The second question asked the level of attention the school provides to their professional development. Of the 62 teachers who responded, only one indicated not receiving any attention from the school; 98.39% of the teachers marked at least, a little, moderate, and a great deal. The school was helpful to teacher professional development.

Teaching Resources and Strategies

The teacher perception survey contained four sections regarding teaching resources and strategies at the site school. Table 17 below shows the responses from the participating teachers.

Table 17

Teaching Resources and Strategies Responses

	Number	Percentage
Do you use PBL in your classroom instruction?		
Yes, always	10	16.13%
Yes, sometimes	30	48.39%
I am not familiar with PBL	10	16.13%
Not at all	12	19.35%
How easy is it to get resources you need to teach in your classroom?		
Extremely easy	9	14.52%
Moderately easy	36	58.06%
Slightly easy	13	20.97%
Not easy	4	6.45%
How effective are instructional methods you use in your classroom?		
Extremely effective	17	27.42%
Moderately effective	42	67.74%
Slightly effective	3	4.84%
Not effective	0	0.00%
How well do you consider the individual needs of students in your classroom?		
Extremely well	32	41.61%
Moderately well	30	48.39%
Slightly well	0	0.00%
Not at all	0	0.00%

The response from this section showed of the 62 respondents, 22 respondents (35.48%) were not familiar with PBL and did not use it in class; 48.39% indicated they sometimes use PBL; and only 10 respondents (16.13%) indicated they always use PBL. The section on the effectiveness of the instructional methods and how well the teachers consider individual needs both reported 100%. The last section of the teacher perception survey had four sections. The first section asked teachers if they use PBL in their classrooms. Of the 62 respondents, 22 respondents (35.48%) were not familiar with PBL and did not use it in their classrooms. The majority of the respondents, 30 (48.39%), indicated they sometimes used PBL in their classrooms. Only 10 respondents (16.13%) marked they always used PBL.

Qualitative Data Findings

Qualitative data came from two different sources which included teacher focus groups and individual teacher interviews. There were two focus groups, one for the STEM teachers and the other for the teachers who teach both STEM and traditional courses. There were two individual teacher interviews, one for the STEM coordinator and one for a department head from the traditional courses.

Teacher Focus Groups

Two focus groups were conducted, one for teachers who teach STEM and traditional students and the second one for teachers who teach STEM students. Both focus groups had six teachers. The two groups were recruited differently to participate in the focus group. The teachers who teach only STEM courses were randomly selected and were able to participate during their PLC scheduled time which is held during the remediation period. Teachers who teach both STEM and traditional courses were first selected randomly, then six teachers from different departments who met on Friday for their PLC meeting were selected to participate. A consent letter was given to all participating teachers to sign, and a copy was given to them for their records. Focus questions were written prior to the event and were designed to answer Research Question 4.

4. What perception do teachers have regarding the overall impact of the STEM program?

Responses from the STEM teachers are identified by the letter assigned to the focus group, and a number identifies the speaker. S1 through S6 identified the teachers who strictly teach STEM courses while TS1 through TS6 identified teachers who teach both STEM and traditional courses.

Teacher Interviews

One-on-one interviews were conducted with two department heads from the school. The first head of the department interviewed was the STEM program coordinator who was purposefully selected. The second head of the department was from the non-STEM department who was randomly selected from the six heads of departments. Both interviews were conducted face to face, audio recorded, and then transcribed verbatim. The participants received letters of informed consent before the interviews were conducted. The interview questions were written prior to the interviews and were designed to address school culture, the goal of STEM program, teacher training, and teaching strategies used in the STEM program. Responses from the interviews are identified by letters. SD indicated responses from the STEM coordinator, while TD indicated the responses from the non-STEM head of the department.

Coding

The focus groups and the interviews were followed by transcription. The documents were then analyzed to determine if any emergent themes were present. Open coding for the different sections followed the following procedure.

1. Transcripts from the two teacher focus groups and the two teacher interviews were created using a word document. This was done separately for each program.
2. The documents were first read thoroughly, and the researcher noted possible

themes and code words.

3. A second reading followed where code words already noted down were examined (Table 18).
4. For the themes, which were already noted, the number of occurrence in the focus group transcripts and the individual interview transcripts was documented. In the event a new theme emerged, it was added to the list and the number of occurrences documented.

Open coding was followed by axial coding.

A total of four themes emerged from the two qualitative sources regarding the perception of teachers towards the STEM program. The different themes, code words, and the number of occurrences are depicted using Table 18. Data collected from both the interviews and the focus groups attempted to answer multiple questions regarding the STEM program at a southeastern high school. The questions were (a) what is the culture of the school and how has the STEM program impacted it; (b) what is the main goal of implementing the STEM program at the school; (c) how do teachers understand PBL; and (d) how much information have teachers learned about STEM program and PBL?

Table 18

Emergent Themes, Code Words, and Frequencies

	Code words	Number of comments from a teacher focus groups	Number of comments from department heads interviews
Teaching strategy/Problem-Based learning/instructional strategies/ progress monitoring	Learn by doing and through discovery;	8	2
	Learning through solving problems;	4	1
	Working together.	5	-
Program goals/ school community members/ factors hindering efforts of the program	Global connections;	6	-
	Different perspectives;	3	1
	Rigor and challenge.	7	1
School culture and cultural changes/ implementation of the program	Diverse;	13	2
	Family oriented;	2	-
	Very inclusive	4	2
Staff development/ workshops	Ongoing;	11	1
	Engaging	7	2

School Culture

Several teachers offered interesting insight regarding the culture of the school. When asked to describe the culture of the school, Teacher S4 commented,

> School culture is diverse ranging from folks that are growing up from rural Environment who are outdoor oriented. Students from middle-class people, people, living in pseudo-suburban areas that are growing outside the city limit. Students that come from homes where education is highly valued, and the students have their self-motivation that drive them forward.

Teachers S3 remarked, “There is a very good mix of all ethnicity in the school among the students and the teachers.” This teacher went on to mention, “even though most the students and the teachers are white, there is still a healthy mix of the other ethnicity.”

Teacher T2 added, “The culture of the school is very positive, a safe environment for the kids. It is very inclusive with a diverse population having students from all backgrounds and ethnicity. We all work together having the same goal in mind.” The two department heads also commented on the culture of the school.

The STEM department head SD commented, “Diverse but also like a big family particularly with the STEM kids who get along very well and you see a brother and sister relationships between the students.” The department head from the traditional program TD added, “The school is diverse, and this allows the students to be exposed to multiple ethnicities, races, religions and learn how to have mutual respect for each other.” The focus group teachers and the department heads also commented on the culture of the school during the implementation of the STEM program.

Teacher S4 mentioned,

> There have been cultural changes within the timeframe of transitioning from a traditional school to a school with STEM program [school within a school]. The school has experienced growth in student population with almost 100 students from each grade level being STEM students.

Teacher S 3 added, “We had surprisingly a decent number of students taking a higher-level course like AP and honors. This has greatly increased with the introduction of the STEM program.” Teacher T4 expressed his opinion that

> the implementation of the STEM program changed the culture of the school. The

> once family oriented school with many cultures saw a divide. The non-STEM teachers and students perceived the program as a program for intelligent students. Their perception changed once the program was implemented, and it has since been integrated into the school.

From the perspective of the department heads, DS stated,

> First, when implementing the STEM program, no one knew what STEM was. At first, the diverse students that we have naturally associated STEM program with Nerds and students who are socially awkward. This was proven wrong as the majority of the students are very normal teenagers who take an extra interest in the engineering aspect of life but are very typical teenagers.

Several changes were noted by the teachers and the department heads attributed to the implementation of the program at the school. Teacher S3 remarked, "I have noticed that STEM has drawn from the AP and honors classes making them smaller in number and quality." The department head DS added,

> Initially there were several biases about the type of students in the STEM program mostly being referred to the as nerdy bunch. This has changed as they are now looked at as the intelligent bunch and a lot of students want to tap into that because they do cool things.

Another positive change is with the resources added to the school.

> Teacher S4 elaborated on the change by adding,
>
> There have been cultural changes within the timeframe of transitioning from teaching traditional courses to teaching STEM courses. One of the changes is in the growth of student population from other high schools in the district. This is because of STEM being a school within a school. Another change is with

technology; the program saw the introduction of 1:1 initiative with the STEM program and has eventually led to all classrooms being equipped with chrome books cart or laptop carts.

Goal of Implementing STEM Program

Several comments were made in both the teacher focus groups and the department head interviews. Among comments that explained the goal of implementing the STEM program was from the department head SD:

> STEM exposes students to global connections by making students learn that there is more out there than being a doctor, lawyer or a teacher. There is a lot of skills based things that students can do beyond what they are typically taught in the classroom.

Teacher S1 added, "to give students a different perspective of learning that does not have to be paper pencil lecture."

Teacher S2 said, "To give students opportunity to take classes that present rigor and challenge them and allow them to dig in fields that they are already in at a younger age." Teacher T5 added, "To move away from the traditional education that involves paper pencil and move to hands-on mathematics based, science based engaged learning." Teacher T3 commented, "As a nation, we are moving towards more STEM type of jobs, making it a good idea to expose children early providing them with options which will enable them to compete in the global arena." The views of the teachers were emphasized by teacher T4 who said, "The goal is obviously not only to increase the Science, Technology, Engineering, and Mathematics learning but to get students to do more individualized research-based work."

The teachers and the department heads all agreed that all of the teachers in the school share the same sentiment when it comes to the goal of implementing STEM in the school. Department head DS commented,

> The school community are all on board and very supportive with the implementation of the STEM program. All stakeholders share the same goal of equipping the students with the best education and helping them in their quest to be competitive in the global arena.

Teachers who are not in the STEM program are supporting the implementation of the STEM program.

Teacher T4 explained,

> All the teachers share the same goal of having a successful STEM program which is evident by the level of involvement from all the teachers in the school. They support the students and the STEM team in different activities like PBL grade level days, judging projects done by the STEM students, attending presentations by the STEM students and helping to host students in their homes from Denmark who participate in the program annually for a week.

Teaching Strategies

One teaching strategy used in the STEM program is PBL. The STEM teachers were familiar with the strategy as they use it as part of their instructions. Responses from the STEM teachers on their understanding of PBL included: Teacher S1, “It is a different way of engaging students in the curriculum where teaching is done through solving problems. It is the process of learning through making projects.” Teacher S2 added, “Students become more inquiry based with their learning or their approach to learning by having a problem or having a product to create. It creates more direction of thought rather than saying there is only one answer.”

The head of the department for SD had this to say about PBL,

> PBL means learning by doing and learning by discovery. In a lecture, the teacher takes the information and relays to students. PBL is the opposite where the teacher presents the problem but does not give all the knowledge. Students must figure out themselves with the teacher being the guide.

Some teachers who teach traditional courses alone were not familiar with PBL but expressed their willingness to learn about it. Teacher T3 commented, “I do not do a lot of that but would like to learn about it.” Other teachers had heard about it, and their responses included: Teacher T4 said, “you give students some real-world problem situations, and they collaborate and do a project.” Teacher T2 added, “students become hands on which increases their chance of them using their higher reasoning and building on their thinking skills.”

DT had this to say about what PBL is: “PBL is not necessarily learning knowledge but is taking the knowledge you have and applying it to figure out a solution based on what you already know and may involve doing more research to come up with a solution.” When it came to how PBL “looks like at the school,” the teachers shared the following: DS said,

> Chaotic . . . organized chaos is the best way to describe PBL in the school. You walk into a classroom, and all you see is a lot of group work, a lot of team building, a lot of doing, fewer papers which make it a very structured environment.

S1 added,

> PBL is a little bit of instruction just to get the students started on a topic and then students going on and doing further research, which ends with them doing a

further hands-on project to gain the rest of the information.

One observation that was made by a teacher who teaches the traditional courses was the day-long, grade-level PBL activities that are carried out occasionally in the school.

Teacher T3 added,

> At our school, we have grade level PBLs where STEM students are excused from their non-STEM classes and participate as a large group for the entire day. Themes are provided as a guide, and the students must work together to solve the issue at hand. For example, recently the 10th grade STEM students were working on research where there was going to be a natural disaster, and they had to figure out how they were going to save the world. That is come up with the best plan based on their content areas.

Teacher Training

The STEM teachers expressed the support they have been getting with training and ongoing support from the administration and the school district.

The department head DS commented,

> Professional development is something we focus on not only in the workplace but outside the workplace. The school district supports this fully by having paid substitute for teachers. So, when it comes to professional development and STEM, T say each teacher gets at least 15-20 hours per year. This does not include the training offered during summer.

Other comments by other teachers about teacher training included: Teacher S5, "We get a lot of professional development opportunities. We had a whole day workshop at the discovery place education which was paid for." Teacher S6 stated, "We get a good amount of professional training which helps with the instructions in the classrooms."

Teacher S7 stated, “We get trained all the time . . . we have weekly meetings with our PLCs to discuss anything we have received training on. Also, professional developments are organized by the district every semester.”

Summary

This mixed-method research investigated the impact of the STEM program on student achievement by comparing the performance of the STEM students with that of the traditional students. Different academic achievement indicators were used in this study which included the EOC state assessment in Biology, Math 1 and English II; the standardized test ACT; and GPAs of the participants at the time of graduation. Data collected included quantitative data from teacher perception surveys and archival data for the participating students such as the number of participants from the two programs, gender, ethnicity, age, GPA scores, ACT scores, and EOC scores from Biology, Math 1 and English II. Qualitative data were collected from teacher focus groups and individual interviews. The findings from this chapter along with their implications are discussed in Chapter 5.

Chapter 5, discussions and implication, presents in sufficient detail a summary of the findings of the study. The chapter has a brief overview restating the purpose of the research, research questions guiding the study, and null hypothesis for each of the research questions. Areas to be included are possible explanations for the findings, limitations and delimitations of the study, implications of the findings, and recommendations for future research and practical applications.

Chapter 5: Discussion

Introduction

This chapter presents a summary of the findings of the study. The chapter has a brief overview restating the purpose of the research and research questions guiding the study. Areas to be included in this chapter are discussion of the findings, conclusions, limitations and delimitations of the study, implication of the findings, recommendation for further research, and a summary of the study. This study was conducted based on the problem that there has been a decline in the ranking of the U.S. on international assessments and lack of interest in the STEM fields (NRC, 2011). The problem is compounded by the U.S. falling short in preparing students for the different occupations requiring STEM knowledge (U.S. Senate Report, 2011).

The launch of Sputnik by the Soviet Union in 1957 was viewed as a major humiliation to Americans which prompted attention to the low quality of mathematics and science education in the U.S. This led to Congress passing the 1958 National Defense Act to increase the number of science and math majors (Klein, 2003a). Additional polices and acts were passed by Congress in an effort to improve the K-12 education system and U.S. competitiveness. Suggestions were made that have led to the implementation of new programs with the STEM program being one of them (PCAST, 2009).

Overview

This mixed-method study investigated the impact of the STEM program on student achievement. The EOC state assessments in Biology, Math 1, and English II were used as academic achievement indicators. In addition, the standardized test ACT and the GPA at the time of the participants' graduation were used. The continued decline in academic achievement of U.S. students as measured by test scores and standardized tests has been a great concern. Several steps and educational acts have been passed to address the issue and hold states, school districts, and schools accountable for their results. In September 2000, a report titled Before It's Too Late was released by the National Commission of Mathematics and Science (Glenn, 2000). The report found that for the U.S. to stay competitive in the global economy, America's students must improve their performance in mathematics and science. ESSA of 2015 built on key areas of progress in education made in recent years.

The research questions guiding the study were

1. To what extent is there a statistically significant difference in the achievement of students who are in the STEM program as opposed to students in the traditional program?
2. To what extent is there a statistically significant difference in the graduation rate of students who completed the STEM program as opposed to students in the traditional program?
3. To what extent is there an association between the professional development activities of STEM faculty and student achievement?
4. What perception do teachers have regarding the overall impact of the STEM program?

Interpretation of Findings

Several efforts have been made to improve student academic achievement both at national and state levels. This has seen the passing of several bills and acts all aimed to improve U.S. education and increase its competitiveness in the world. The STEM Education ACT of 2015 which is an amendment of the NSF Act of 2002 requires NSF to continue with the award of competitive merit-reviewed grants to support the expansion of research and training opportunities for math and science teachers. The STEM Act is an ideal starting point to ensure that federal education and workforce programs are aligned with the needs of today's students and our future economy (STEM Education Coalition, 2015).

Learning and teaching strategies that involve the use of project-based and hands-on learning which is prevalent in STEM programs require significant investments of time and training for both educators and students. Federal funding for STEM education has increased to almost 3 billion, and several school systems have continued to introduce and implement STEM programs (NSF, 2011). PBL is one instructional strategy used by STEM programs. This involves higher level cognitive tasks such as scientific processes and mathematic problem solving. The opportunity to communicate and collaborate with peers and teachers stimulates students to construct their knowledge and make use of formative feedback which is important in developing higher thinking skills (Capraro & Yetkiner, 2008).

Improving academic achievement is critical for the nation, and federal funding is tied directly to the attainment of acceptable academic achievement levels. The STEM careers offering higher paying job opportunities attract an educated workforce, which will support other businesses to meet the social needs of communities (Reardon & Bischoff, 2011). STEM education will be beneficial to students due to the STEM fields expanding quickly. By 2018, one in 20 global jobs will be STEM related which is an estimated 2.8 million jobs. STEM-related skills are not just a source of jobs but are a source of jobs that pay very well (U.S. Department of Labor, 2015). This makes encouraging student interest in these careers very important.

The goal of the study was to examine the impact of the STEM program on the academic achievement of high school students as compared to the traditional program. Several studies to validate STEM programs and their effectiveness have been conducted at different levels. The study was conducted because there was a need to gather information from a current STEM school with both the traditional and STEM programs and compare how the two groups perform using standardized tests as indicators and evaluate the effectiveness of a STEM program at a high school level.

This mixed-methods study attempted to answer the four research questions. To answer the first research question, "To what extent is there a statistically significant difference in the achievement of students who are in the STEM program as opposed to students in the traditional program," archival data from the participants such as gender; ethnicity; age; ACT scores; and EOC scores from Biology, Math1, and English II were used. The second research question, "To what extent is there a statistically significant difference in the graduation rate of students who completed the STEM program as opposed to students in the traditional program," was answered using the archival data of the participating student GPAs at the time of graduation and school documents with the graduation rates of the participants.

The participating students consisted of 65 STEM students and 65 traditional students. An Independent Samples *t* Test was run to determine if there were differences in the mean scores between the two programs using the EOC scores from Biology, Math 1, and English II. The test was also run to determine if there was a difference in the mean scores between the programs using the standardized test ACT.

The quantitative data for the ACT scores were analyzed and revealed that there was a nonstatistically significant difference between the programs. The extent of the difference was small with the mean difference between the groups being 2.02. The *p* value was 0.09 favoring the STEM students. Although there was no statistical significance, the *p* value was close to approaching marginal significance. Scores for biology for both programs were analyzed and revealed that there was a nonstatistically significant difference between the programs. The extent of the difference was small with the mean difference between the groups being .28. The *p* value was .069, a value short of significance. The results favored the STEM students.

The scores from Math 1 were analyzed and revealed that there was a nonstatistically significant difference between the programs. The extent of the difference was small with the mean difference between the groups being .17. The *p* value was .284 favoring the STEM students. The quantitative data for English II scores were analyzed and revealed that there was a nonstatistically significant difference between the programs. The *p* value was .235 favoring the traditional students. The course content covered and how it was taught to the programs did not result in a statistically significant impact on the test scores. The extent of the difference was small with the mean difference between the groups being .17.

The STEM program students outperformed the traditional program students in Biology, Math 1, and ACT scores. The traditional program students outperformed the STEM students in English II and had a higher mean average GPA score. The preferred learning style of students by both pathways may have resulted in student success. The traditional program students had a slightly higher mean average GPA score than the STEM students. This may be attributed to the curriculum pathway the STEM students undertake (Appendix M). All STEM students are required to take honor courses with AP courses as early as ninth grade. The students take all core honor classes and some AP courses which are not the case with the traditional students who have the option of taking the courses later in high school. This gives them an advantage when it comes to a higher GPA from as early as ninth grade.

A Chi-Square Test of Independence was conducted to determine whether there was an association between gender type and the STEM program. The results showed there was a statistically significant association between gender type and the STEM program $\chi 2$ (1) = 12.381, $p < .001$. The test does not inform on the magnitude of association; Cramer's V was used to provide an estimate of the strength between the variables. The results showed that the association was moderately strong, Cramer's V=.309. According to American Association of University Women (AAUW, 2015), as early as in elementary level, children have developed a sense of gender identity and have developed unconscious bias associating boys with math and science. By high school, fewer girls than boys plan to pursue STEM programs with male students twice as likely as female students to enter STEM fields. The STEM program participants had 45 male students and 20 female students.

A Pearson R correlation was run to determine associations between teacher perceptions and student achievement. The three areas that were used for the teacher perception survey were how prepared students are in the classroom, engagement level of the students, and how motivated the students are. In all the three areas, there was a very positive association for the STEM teachers, $r = 1$, $p <.000$. This was unlike the responses from the teachers who teach both STEM and traditional courses, where a negative correlation was reported for the three areas. Student-centered classrooms tend to have greater engagement compared to the traditional classroom. One method that can be used to build a student-centered classroom is PBL. According to research, when students gain autonomy of their work, they tend to be more engaged and motivated (Headden & McKay, 2015). PBL gives students control of their work and gets them involved in the entire process from conception to completion (Headden & McKay, 2015). Projects that have depth, duration, and complexity will challenge students and motivate them toward the construction of knowledge. This explains the positive association between STEM teacher perceptions and student level of engagement among the students.

Level of Student Engagement

The section level of student engagement of the teacher perception survey was used to run the Pearson R Correlation explained above. Motivation and engagement are critical in the learning processes (Kamil et al., 2009). If students are not motivated, they will not benefit from the instruction as motivation eventually leads to engagement (Kamil et al., 2009). This makes motivation important to provide the entry point for teachers (Guthrie, 2008). Nevertheless, engagement is still critical, because the level of engagement over time is the vehicle through which classroom instruction influences student outcomes (Guthrie, 2008).

To effectively implement PBL in the classroom, educators must first motivate and engage their students. Bruner (1971) argued students need to be intrinsically motivated in what they are learning rather than being motivated by external rewards. The level of interest in a task improves the student attitudes to learning. The discovery and problem-solving nature of PBL requires students to hypothesize, ask questions, and work together in groups to solve problems. This provides students with challenging opportunities which require a level of involvement and engagement leading to cognitive development (Bruner, 1971). Learners who can see the connection between a project-based task and the real world will be more motivated and be in a better position to solve the problem at hand. PBL provides learners the opportunity to have a voice in how and what they learn while building intrinsic motivation toward problem solving (Headden & McKay, 2015).

Different documents were inspected to determine the graduation rate of both groups. The graduation rate of all students during the academic year 2015-2016 was reported as 92.7% on the North Carolina public school's accountability service division website (Appendix J). The North Carolina report card reported a 93% graduation rate for the same school year (Appendix K). All 130 participating students from the STEM and traditional programs graduated, resulting in a graduation rate of 100%.

To attempt to answer the last two research questions, a teacher perception survey was issued to teachers, and the results were analyzed. Teacher focus groups and individual teacher interviews were also conducted to attempt to answer the questions listed below.

3. To what extent is there an association between the professional development activities of STEM faculty and student achievement?
4. What perception do teachers have regarding the overall impact of the STEM program?

The analysis of the teacher perception survey results was divided into three sections: professional development, teaching resources and strategies, and the level of student engagement which has been discussed under Pearson R Correlation. The survey was administered electronically and by hard copy to all teachers. A total of 62 teachers completed the survey with most of the teachers being the ones who teach traditional courses alone. The discussion of the findings for each section follows based upon information reported in Chapter 4.

Professional Development

The teacher perception survey contained two sections regarding professional development at the school. The first question asked about how many times a week do teachers collaborate in their PLC. The majority of the respondents indicated they collaborate at least once a week. The second question asked about the level of attention the school provides to teacher professional development. Overall, all participating teachers but one expressed satisfaction.

The literature review of this research discussed the professional development offered to STEM teachers. Most of the teachers teaching STEM courses are graduates who have majored in mathematics who studied calculus, engineering, physics, chemistry, and other STEM subjects. Professional development and teaching strategies are offered on the job. Professional development offered to STEM teachers on implementing STEM PBL are successful in increasing teacher self-efficacy and improvement of classroom practices (Hmelo-Silver, 2004; Shin et al., 2010). Teachers who completed the professional developments were able to use more standard-based teaching practices and informal assessments than they did prior (Zhang et al., 2011). Additional self-paced training is offered to STEM teachers through NASAePDN, an Electronic Professional Development Network (National Education Association, 2015).

Students learn better from more qualified teachers. Several studies indicate that professional development contributes to teacher quality and student achievement. The teacher perception survey had a question regarding professional development at the school site. The teachers were asked about the level of attention the school gives to teacher professional growth. Of the 62 teachers who responded, only one indicated not receiving any attention from the school; 98.39% agreed the school was helpful to teacher professional growth. The purpose of professional development for teachers is to improve their content and pedagogical knowledge which has a positive influence on student academic achievement. Professional development that is sustained, aligned with the curriculum, and focused on instruction is shown to positively influence student achievement (Kannapel & Clements, 2005). Teacher quality and fidelity in implementing STEM PBL are closely related to student improvement in academic achievement. Bruner's (1971) discovery learning theory stressed the importance of having professional development activities geared toward deepening and extending learning practices. He also highlighted the need for teachers to work collaboratively, especially in situations where cognitive acceleration strategies can be applied. Teachers who use cognitive strategies effectively in their teaching could coach others in their use, which in turn benefits the students (Bruner, 1971).

Teaching Resources and Strategies

The last section of the teacher perception survey had questions about PBL, the effectiveness of the instruction methods used in classrooms, and how well teachers considered needs of individual students. The STEM teachers and teachers who teach a combination of STEM and traditional courses were familiar with PBL and used it often, while most of the teachers who teach traditional courses were not familiar with PBL and did not use it in their instructions. Most of the teachers indicated they consider the needs of the students and use effective methods of instruction in their classrooms. This is a clear indication that the teachers are confident the instructional methods they are using are yielding the intended results. When effective instructional strategies are implemented, a percentile gain of 29-45 points in student achievement can result (Marzano et al., 2001). The increase will mean an increase in the score of an average student at 50th percentile might rise to the 79th or even the 95th percentile (Marzano et al., 2001).

Meeting the needs of each student in a classroom can be time consuming and a monumental task for teachers. Despite the work involved, it is very important in preparing students to be effective lifelong learners. Students should be allowed to approach the curriculum as they are able, to the extent that better enables them to retain information provided, hence improving student excitement for learning. PBL is an interdisciplinary teaching and learning approach that involves hands-on activities, collaboration, team communication, knowledge construction, and formative assessment as the primary components for PBL (Barron et al., 1998). This is in higher level cognitive tasks such as scientific processes and mathematic problem solving. The opportunity to communicate and collaborate with peers and teachers stimulates students to construct their knowledge and make use of formative feedback which is important in STEM PBL classes (Capraro & Yetkiner, 2008).

PBL has been shown to improve student understanding of science, problem-solving skills, and collaboration skills to a greater extent than traditional methods (Geier et al. 2008; Yazzie-Mintz, 2010). In addition, STEM being an interdisciplinary curriculum increases student engagement and learning (Parsons & Taylor, 2011). Barrows's (1986) theory of PBL stresses the importance of having instructional principles that are based on the assumption that learners are constructors of knowledge gained. The learning environment should be developed to encourage active participation of students. The sense of community instilled in project-based classrooms with students working through complex problems gives them equal opportunities to contribute and develop a feeling of belonging in students (Hullemann & Harackiewicz, 2009). In PBL classrooms, students are also encouraged to connect to real life situations which make them take greater ownership of their learning and engagement increases (Hullemann & Harackiewicz, 2009).

Teacher focus groups and individual interviews yielded four emergent issues that help the two last research questions.

3. To what extent is there an association between the professional development activities of STEM faculty and student achievement?
4. What perception do teachers have regarding the overall impact of the STEM program?

There were 20 comments made about teaching strategy, PBL, and instructional strategies using code words like learning by doing and through discovery, learning through solving problems, and working together. Teachers teaching STEM and those teaching STEM and traditional courses were familiar with PBL and offered comments: “it is learning by doing and learning by discovery” and “students become more inquiry based with their learning.” Teachers who teach traditional courses only had little or no knowledge about the strategy.

The second theme had a total of 18 comments positively supporting the goals of the STEM program at the site. Code words included global connections, different perspectives, and rigor and challenge. One of the comments made by the teachers about the goal of the program was, “exposes students to global connections.” This is key in making U.S. students competitive in the global arena. All teachers in the STEM and traditional program at the site agreed that all teachers share the same goal for the STEM program. In addition to providing global connections, comments about a challenging curriculum were made. One teacher commented, “the program provides students with an opportunity to take classes that present rigor." This will put them in a better position to compete with their counterparts in the world.

School Culture

To understand the changes that were brought with the introduction of the STEM program, it was important to understand the culture of the school before and after the implementation of the program. Comments about the school culture included code words like diverse, family oriented, and very inclusive. Teachers from the traditional program agreed that there is a very good mix of all ethnicities in the school among the students and the teachers: "it is very inclusive with the diverse population having students from all backgrounds and ethnicity." Multiple teachers and the head of the STEM department recounted a cultural change within the timeframe from traditional school to a school with the STEM school. The school has experienced growth in student population from other schools in the school district. The program has also drawn from AP and honor classes making them smaller in size and quality. Other information from the focus groups showed an increase in technology that has seen the introduction of a 1:1 initiative with the STEM program and has eventually led to all classrooms being equipped with chrome book carts or laptop carts.

The culture of a school consists of the underlying norms, values, and beliefs that teachers, administrators, and school staff hold about teaching and learning. Schools have assumptions about which teaching techniques work well, how critical staff development is, and how the team reacts to change (Deal & Peterson, 2010). Schools with a positive culture tend to have a set of values that supports teacher professional development, a sense of responsibility for student learning, and a positive caring atmosphere (Deal & Peterson, 2010). School culture affects several aspects of a school. It affects teacher attitudes toward improving instruction and motivation to attend different activities like professional developments and workshops (Deal & Peterson, 2010. Teachers, administrators, and staff in a positive school culture believe in themselves and have the ability to achieve their goals more successfully. The responses from the focus groups and the individual interviews portray a school with a positive culture. The teachers shared a common goal of equipping the students with the best education. In addition, the teachers shared the same sentiment when it came to the goal of implementing STEM in the school and received support from the administrators when it came to teacher growth through staff development and workshops.

The last theme, staff development/workshops, had 21 comments with code words ongoing and engaging. Teachers from the STEM program expressed their satisfaction with the attention provided to them with numerous training and staff developments. The department head of the STEM program commented, "Professional development is something we really focus on." The teachers agreed they get a good amount of professional training which helps them with the instructions in the classrooms.

Conclusions

The STEM and traditional students demonstrated similar results on all standardized tests. Students have different strengths and preferences in the way they take in and process information. Research supports that the style by which students learn and apply knowledge is an important component to consider in the aggregate educational process (Gokalp, 2013). This is an indication that the preferred learning style by the students is key in motivating and engaging students and the ultimate success of the students. The four indicators ACT, Biology, Math 1, and English II had a nonstatistically mean score ($p > .05$). There was no statistically significant mean difference between the programs, and therefore we can accept the null hypothesis that states: There is no statistically significant difference in the achievement and graduation rate of students in the STEM and traditional programs.

The traditional students had high mean GPA scores as they are not exposed early to AP and honor courses which is the case with STEM students. The preferred learning style of students by both pathways may have resulted in the overall student success in both programs. The AP and honor courses are more rigorous and academically challenging to the students which may lead to low GPAs at the start of high school. The traditional students are introduced to AP and honor courses much later during tenth grade making it possible to have high GPAs from ninth grade. The STEM students had a higher ACT mean score which is an indication that the academic rigor of the courses they take in ninth and tenth grade prepares them for the standardized test in comparison to the traditional students.

The effects of STEM PBL have been reported with several studies supporting the positive impact on student content knowledge (Boaler, 1997; Barron et al., 1998; Liu & Hsiao, 2002). Olivarez (2012) investigated the impact of the STEM program on academic achievement. The conclusion was that participation in a STEM academic program where teachers use PBL positively impacted student achievement. In this study, there was a significant association between professional development, student engagement, PBL, and student achievement. This is a clear indication that academic achievement success of students is dependent upon several factors and not only based on one factor.

Responses from the teacher satisfaction survey and comments made by the teachers during the focus groups and individual surveys suggest that there is a positive association between the professional development activities of STEM faculty and student achievement. Also, teachers have a positive perception regarding the overall impact of the STEM program, and therefore we can reject the null hypothesis and accept the alternative hypothesis that states: There was an association in student achievement based on the professional development activities that STEM faculty participates in. This relates to prior research conducted and discussed in Chapter 2. Han (2013) analyzed the impact of professional development on teacher understanding and implementation of STEM PBL. The findings of the study showed STEM PBL instruction positively influenced student achievement. In addition, attendance in PBL professional development significantly correlated with quality of the in-class PBL implementation. One study by Shin et al. (2010) reported professional developments implementing STEM PBL have shown an increase in teacher self-efficacy and improvement of student achievement. STEM PBL not only increases self-efficacy in teachers but also in students. Self-efficacy is positively related to student interest and engagement (Pajares & Schunk, 2002).

Teacher overall perception in this study about the STEM program was recorded from the focus groups, individual interviews, and the teacher perception survey. Teachers expressed satisfaction when it came to the professional development offered to them by the school and the school district. The numerous training and professional development activities were helpful with classroom instructions. Teachers were also confident with the instructional strategies they used in the classrooms in yielding the intended results. Also, the teachers interviewed and those who participated in the focus groups positively supported the goals of the STEM program at the site in exposing students to a challenging curriculum and the global arena. On the other hand, when it came to the students, results from this research has shown an increased level of engagement and motivation among STEM students. Self-efficacy predicts initial engagement and task performance; and this success leads to greater intrinsic interest and a greater likelihood of engaging in that task in the future, often at a more challenging level. Watt (2006) found that individuals with high self-efficacy enroll in more challenging courses than individuals with low self-efficacy. This is evident from the STEM pathway (Appendix M) that is followed by STEM students.

Limitations and Delimitations

The first limitation addresses the timeframe for this study. The study was conducted when the student participants had already graduated. Using data 4-years old when the first STEM students were in ninth grade may present a limitation in generalizing in the present use. In addition, not having the participants present to provide their perceptions of the program may not provide a clear picture of the program. The second limitation of the study was the size of the population. Internal validity might have been affected as random sampling was not conducted with the STEM students. The reason for this being that are approximately 100 STEM students per grade level. For this participant group, which was the first graduating STEM class, the number was only 65 STEM students. The delimitation for this study was the fact that the study was conducted in one high school in North Carolina. Due to the nonprobability nature of sampling, external validity was limited to study participants.

Implications for Practice

This mixed-method research study reveals several implications for STEM education in the U.S. Current and future jobs which will allow Americans to prosper are concentrated in fields that involve STEM skills. A report from Georgetown University Center on Education and workforce found that 65% of those with bachelor’s degrees in

STEM fields earn more than those with master's degrees in non-STEM occupations. The number of jobs available in any nation fuels its economy. STEM careers are among the nation's fastest growing fields with 10 fastest growing occupations from 2008-2018 being STEM occupations (U.S. Department of Labor, 2015). By 2018, one in 20 global jobs will be STEM related which is an estimated 2.8 million jobs. STEM-related skills are not just a source of jobs but are a source of jobs that pay very well. Workers in STEM occupations earn 26% more compared to their counterparts in other jobs and experience less joblessness (U.S. Bureau of Labor Statistics, 2014). U.S. students who are unprepared to meet the criteria required for STEM occupations will be unable to compete for those high-paying jobs.

For the U.S. to be competitive in the global arena in education and especially in STEM disciplines, it is imperative to find ways to increase student achievement to meet the educational requirements of STEM careers. An instructional strategy like PBL which has been proven to increase student motivation and engagement will lead to increased interest in STEM courses in high school. If U.S. students are not adequately equipped to meet the demands of the growing STEM careers, highly qualified applicants from other countries will fill the jobs.

Curriculum standards for STEM courses are clearly articulated, rigorous, and coherent and help to equip students with skills that prepare them to be successful in college and professional STEM careers. Also, research has proven that students whose teachers connected the content across different STEM courses using PBL are more likely to complete a STEM major than their peers who did not experience these experiences (National Academies of Science Engineering Medicine, 2015). In addition, research has proven that strategies used in STEM increase motivation, engagement, and achievement in students. Professional development and in-service training increase teacher self-efficacy and confidence in delivering content. The rigorous and challenging curriculum used by the STEM program exposes STEM students to AP and honor courses which prepare them for college courses. This makes the transition to college easier for them compared to their counterparts.

Recommendations for Further Study

The STEM program has seen a lot of changes and improvement since its inception in the school. With this being the first group of students graduating from the STEM program, a follow-up study would be beneficial to see if the growth of the program might impact the performance of the STEM students. Involving the participating students in the study using a qualitative component into future research may provide student perspective regarding the advantages and disadvantages of participating in the STEM program. Student perspectives could provide insight into what motivates and challenges them in an academic setting.

A longitudinal study to track the progress of students who participated in STEM programs in middle school through high school and college level could provide valuable feedback on the effectiveness of the STEM program in preparing college-ready students. Additionally, an analysis of the courses the students took, their performance in the different courses, and the GPA after 4 years of college will be valuable feedback. Last, studies to identify characteristics of highly effective PBL teachers to create guidelines for STEM teacher training, professional development, and on-the-job training can provide justification for the investment of time and resources required to implement successful a STEM program.

Summary

A southeastern high school has the first STEM magnet high school program in the school district. The first students of the program graduated during the 2015-2016 school year. The study investigated the impact of the STEM program on the academic achievement of high school students as compared to the traditional program. The indicators used were the graduation rate of the high school seniors, EOC state assessment, and the standardized test ACT. A mixed-method research was used with four research questions guiding the study. The source of quantitative data was a teacher perception survey completed by both STEM and traditional teachers. Archival data for 130 student participants were used to provide information on gender; ethnicity; age; GPA scores; and EOC scores from Biology, Math 1 and English II. Qualitative data came from teacher focus groups, individual interviews, and document analysis.

Data were examined seeking answers to the first two research questions. All of the academic achievement indicator areas showed there was no statistically significant difference in the mean average for ACT, Biology, Math I, and English II. This led to the conclusion that there was no statistically significant difference in the achievement and graduation rate of students who were in STEM and traditional programs. The qualitative data from teachers who were surveyed and those who participated in the focus groups and individual teacher interviews showed there was an association in student achievement based on the professional development activities in which the STEM teachers participated. Also, the participating teachers had a positive perception regarding the overall impact of the STEM program. The study showed the rigorous and challenging STEM curriculum increased motivation, engagement, achievement, and self-efficacy among the STEM students. Staff development and in-service training for the STEM teachers equipped them with the ability to effectively instruct and facilitate instructions in a STEM classroom.

With this being the first group of students graduating from the STEM program, a follow-up study would be beneficial to see if the growth of the program might impact the performance of the STEM students. Other studies that would be beneficial include a study of students regarding their perceptions of the program, a longitudinal study to follow the students until they graduate from college, and a study to identify characteristics of highly effective PBL teachers that will help to create guidelines for STEM teacher training and professional development.

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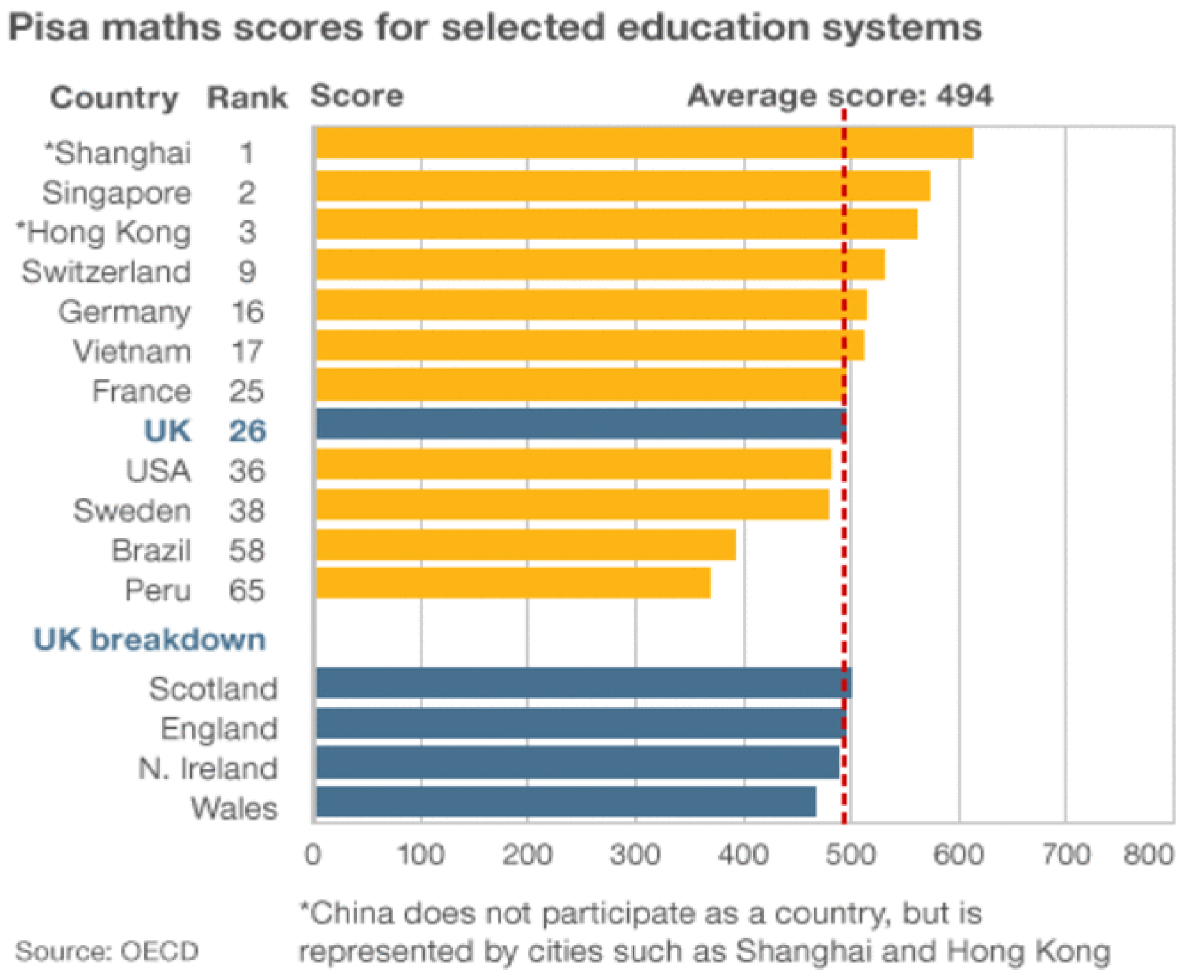
Appendix A

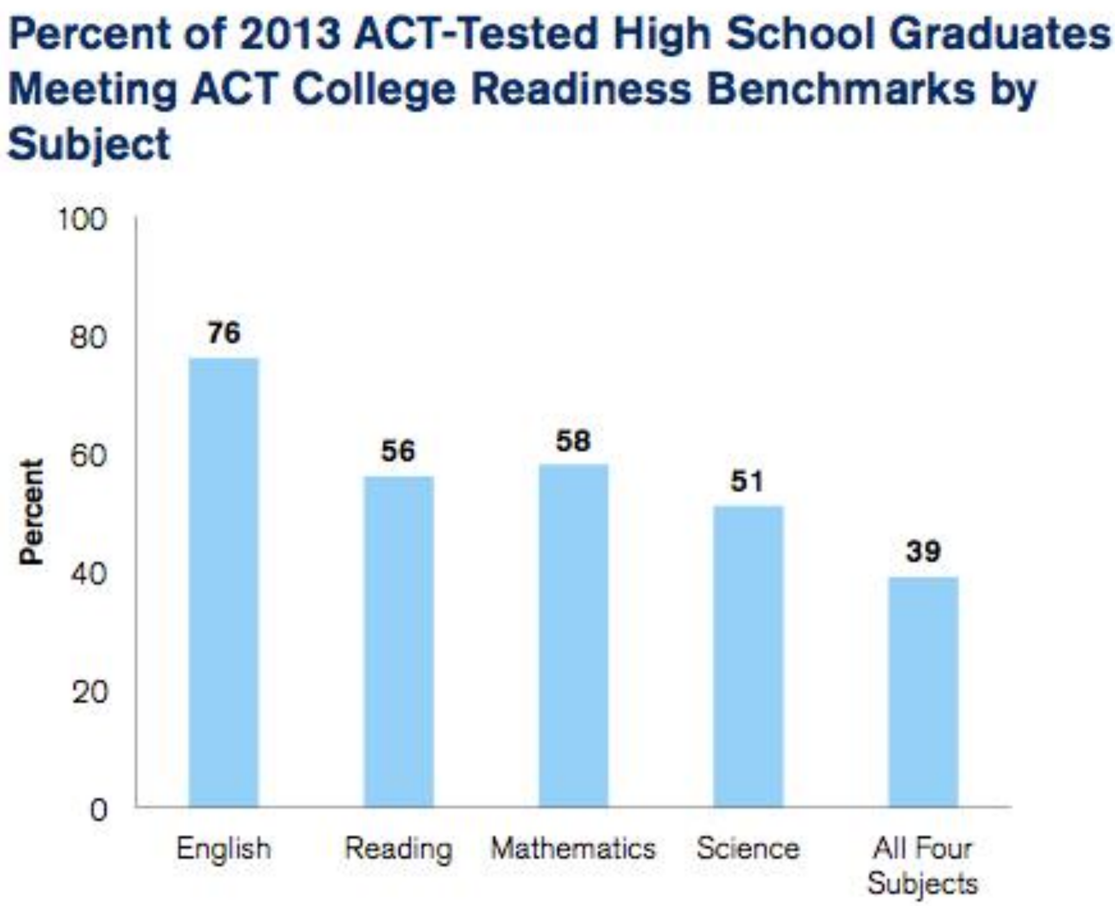
PISA Scores for Selected Education Systems

PISA Math Scores for Selected Education Systems



Appendix B
:
High School ACT College Readiness

High School ACT College Readiness

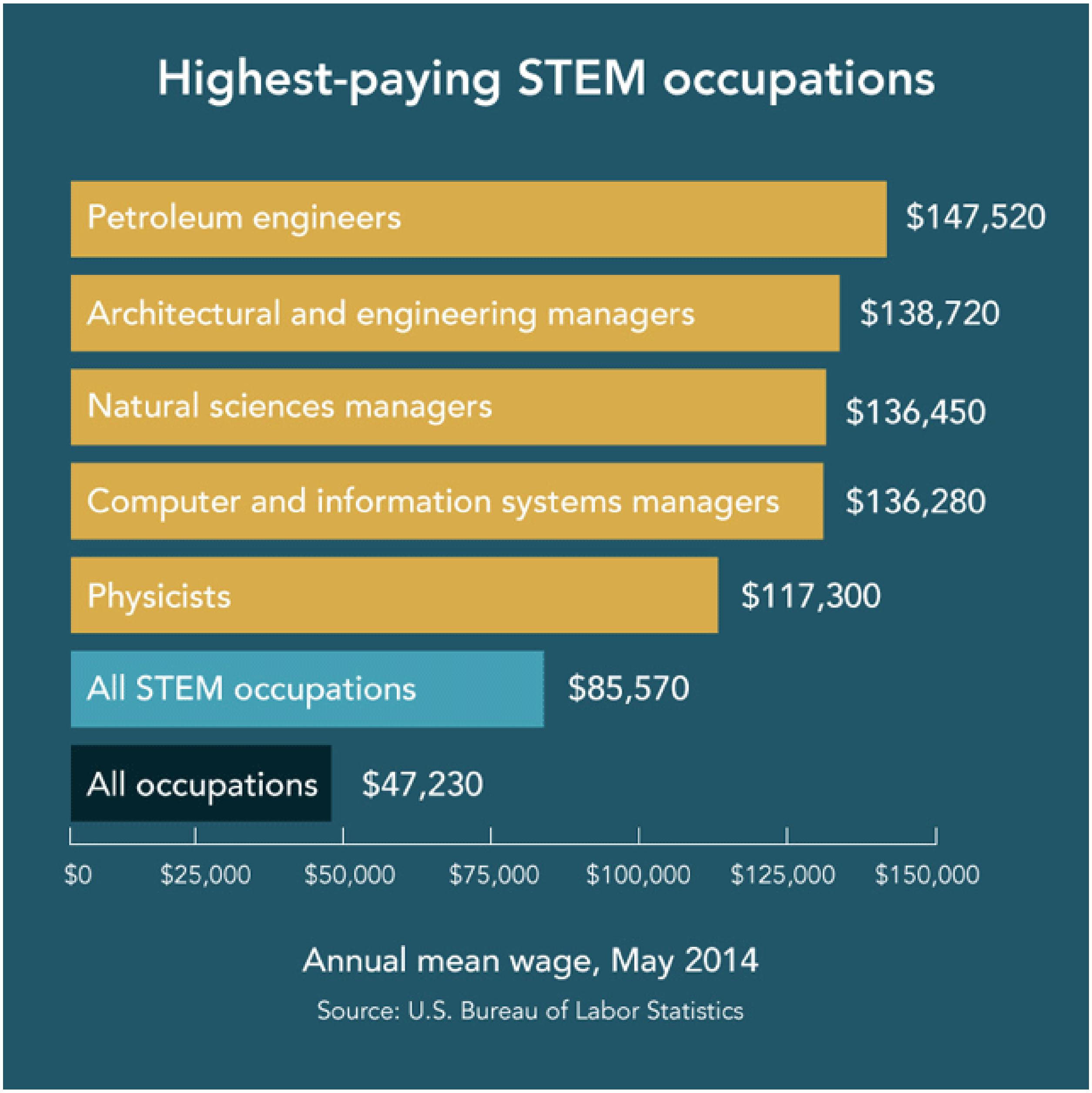


Source: My College Options

Appendix C

Highest Paying STEM Occupations

Highest-paying STEM Occupations



Appendix D

Teacher Perception Survey

Teacher Perception Survey

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1. Do you teach STEM courses; Traditional courses; or STEM and Traditional courses?

- STEM courses
- Traditional courses
- STEM and Traditional courses

2. How often do you collaborate with the members of your Professional Learning Community (PLC) team?

- Not at all
- 1-2 times a week
- 3-4 times a week
- Every day of the week

3. How much attention does the school give to your professional growth?

- A great deal
- Moderate
- A little
- None

4. How prepared are the students when they come to your class on a daily basis?

- Extremely prepared
- Moderately prepared
- Slightly prepared
- Not prepared

5. What is the level of engagement among your students?

- Extremely engaged
- Moderately engaged
- Slightly engaged
- Not engaged

6. How motivated are students in your classroom?

- Extremely motivated
- Moderately motivated
- Slightly motivated
- Not motivated

7. Do you use Problem Based Learning (PBL) in your classroom instruction?

- Yes, always
- Yes, sometimes
- I am not familiar with PBL
- Not at all

8. How easy is it to get resources you need to teach in your classroom?

- Extremely easy
- Moderately easy
- Slightly easy
- Not easy

9. How effective are instructional methods you use in your classroom?

- Extremely effective
- Moderately effective
- Slightly effective
- Not effective

10. How well do you consider the individual needs of students in your classroom?

- Extremely well
- Moderately well
- Slightly well
- Not at all

Appendix E

Focus Groups Prompts

Focus Group Prompts

1. Describe your school culture.
2. Can you describe the culture of the school during the implementation of the STEM program?
3. Since the program's inception, what kind of changes, if any, have you noticed within your school?
4. Would you say there has been a cultural change?
5. What are some aspects of the school culture that has greatly affected the implementation efforts of the program in a positive way?
6. What factors have hindered the implementation of the STEM program?
7. Do you think the school community are on board with the implementation of the STEM program?
8. What is the main goal of implementing the STEM program at the school?
9. What are some factors that have hindered implementation of the STEM program?
10. What is your understanding of Problem-Based Learning (PBL)?
11. Do you use PBL in your daily instruction?
12. Please describe what PBL "looks like" at your School.
13. Do you collaborate with members of your PLC?
14. How often do you meet as a PLC?
15. Does your school or district offer staff development related to your courses?
16. Is the staff development relevant to your teaching?
17. How much more information has you received/learned about STEM program and PBL?
18. Where did you learn more about STEM program and PBL?
19. Are you satisfied with the information and resources provided to teach STEM courses?
20. Has the information changed your instructional practices?

Appendix F

Individual Interview Prompts

Individual Interview Prompts

1. Describe your role as a stakeholder within the STEM program.
2. Who are the other stakeholders in your department?
3. Describe your school culture.
4. Can you describe the culture of the school during the implementation of the STEM program?
5. Since the program's inception, what kind of changes, if any, have you noticed within your school?
6. Would you say there has been a cultural change?
7. What are some aspects of the school culture that has greatly affected the implementation efforts of the program in a positive way?
8. What factors have hindered the implementation of the STEM program?
9. Do you think the school community are on board with the implementation of the STEM program?
10. What is the main goal of implementing the STEM program at the school?

Appendix G

Request for permission letter

Request for Permission Letter

Gardner-Webb University
110 S Main St,
Boiling Springs, NC 28017

The Principal
******* ******** High School
**** *****
7th July 2016

Dear Sir,

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I am a registered Doctoral candidate in the Department of Curriculum and Instruction at Gardner- Webb University in Boiling Springs. My dissertation chair is Dr. Mary Beth Roth. The proposed topic of my research is A Comparative Study of Two Graduation Pathways: Traditional vs. STEM at a Southeastern High School. The objectives of the study are:

I) To gain an in-depth understanding of the impact of STEM program on student achievement using standardized tests (EOC, ACT and SAT).
II) To determine the graduation rate of the STEM students and the traditional students at a Southeastern High School.

I am hereby seeking your consent to gather data pertaining to the study through administering the survey, conducting interviews and focus groups to teachers and analyzing results of participating students who enrolled in the 2011-2012 school year. Should you require any further information, please do not hesitate to contact me or my dissertation chair. Our contact details are as follows:

Email: *********@gardner-webb.edu Tel: 704 *** ****
Email: *****@gardner-webb.edu Tel: 704 *** ****

Upon completion of the study, I undertake to provide you with a bound copy of the dissertation.

Your permission to conduct this study will be greatly appreciated.

Yours sincerely,
Chemisi Kogo – Masila

Appendix H

Permission Granted Letter

Permission Granted Letter

*********** High School
****** HWY 49 S
*********, NC *****

Gardner- Webb University
110 S Main St,
Boiling Springs, NC 28017

August 22, 2016

Dear Mrs. Kogo-Masila:
As the principal of ******* ******** High School, I grant you permission to conduct your doctoral research during the 2016-2017 school year. We are supportive in your efforts to complete your research on A Comparative Study of Two Graduation Pathways: Traditional vs. STEM at a Southeastern High School.
I give you consent to gather data pertaining to the study through administering the survey, conducting interviews and focus groups to teachers and analyzing results of participating students who enrolled in the 2011-2012 school year.
I wish you continued support in your study,
Sincerely,

Andrew ********
Principal
******* ******* High School

Appendix I

Consent Form

Consent Form

Title of Research

A comparative study of two graduation pathways: Traditional vs. STEM at a Southeastern high school.

Researcher

Chemisi Kogo - Masila

Dissertation Chair

Dr. Mary Beth Roth

Purpose of Research

The purpose of this mixed-methods research is to gain an in-depth understanding of the impact of STEM program on student achievement. The End of Course (EOC) state assessment and standardized test American College Testing (ACT) will be used as the academic achievement indicators. The information will be used to determine the graduation rate of the STEM students and the traditional students.

Confidentiality

Confidentiality will be assured to all participating teachers as no names will be associated with the data to be collected. Pseudonyms will be used for all participants and recordings for the interviews and focus groups will be locked for one year after study then erased. The researcher will discuss the issue of privacy by asking interview and focus group participants the need for keeping the proceedings confidential.

Taking part in this study is completely voluntary, and if you have any questions, you may contact Chemisi Kogo -Masila at 704-701-0432 or chemisi@yahoo.comYou will be given a copy of this form to keep for your records.

Statement of Consent: I have read the above information, and I have received answers to any questions I asked. I consent to take part in the study.

Your Signature_____________________________________ Date ___________________

Your Name (Printed) ____

In addition to agreeing to participate, I also consent to having the interview tape-recorded.

Your signature_____________________________________ Date ___________________

Signature of person obtaining consent _____________________ Date ________________

Printed name of person obtaining consent ________________________ Date __________

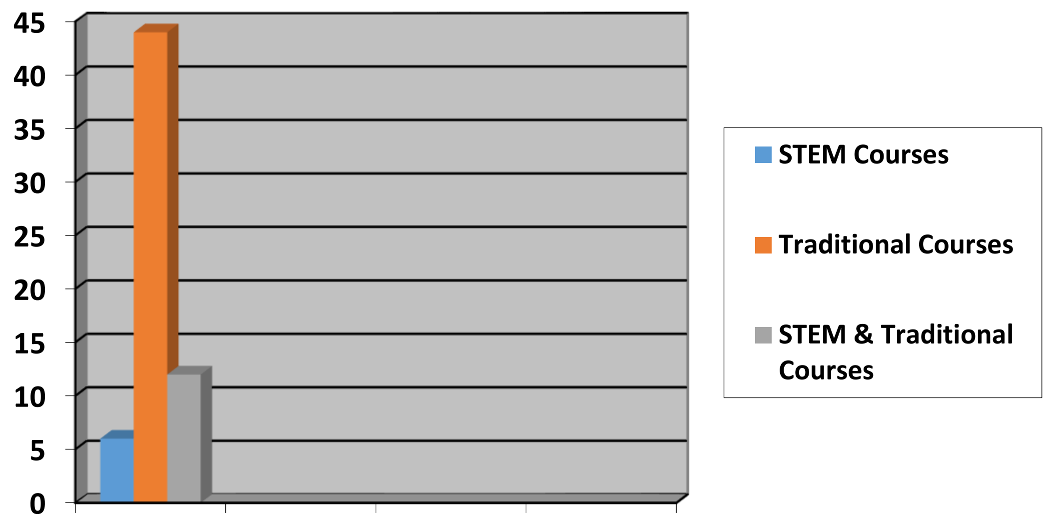
This consent form will be kept by the researcher for at least one year beyond the end of the study.

Appendix J

Teacher Perception Survey Responses

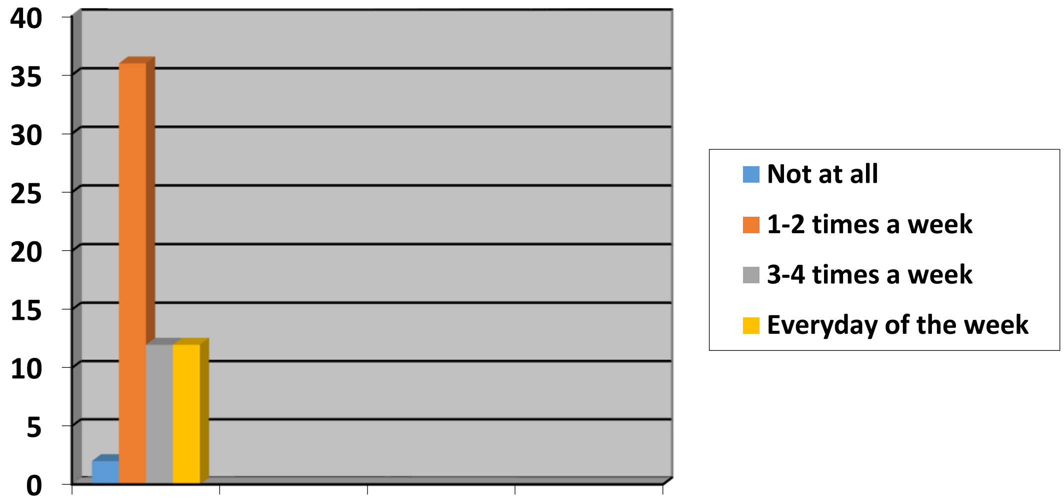
Teacher Perception Survey Responses

Q1. Do you teach STEM courses; Traditional courses; or STEM and Traditional courses?



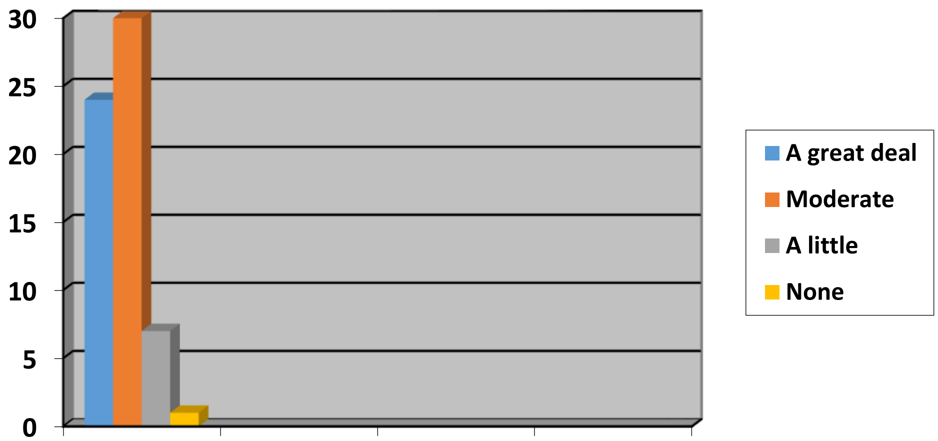
Courses	Number	Percentage
Stem Courses	6	9.68%
Traditional Courses	44	70.97%
STEM & Traditional Courses	12	19.35%

Q2. How often do you collaborate with the members of your Professional Learning Community (PLC) team?



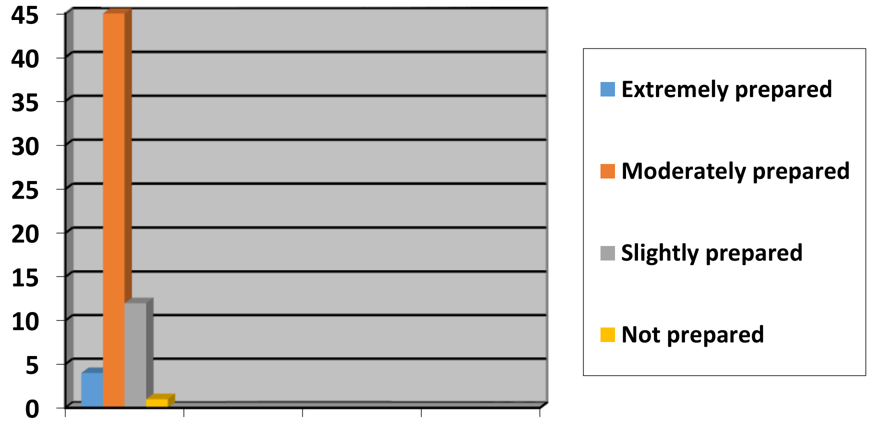
	Number	Percentage
Not at all	2	3.23%
1-2 times a week	36	58.06%
3-4 times a week	12	19.35%
Every day of the week	12	19.35%

Q3. How much attention does the school give to your professional growth?



	Numbers	Percentage
A great deal	24	38.71%
Moderate	30	48.39%
A little	7	11.29%
None	1	1.61%

Q4. How prepared are the students when they come to your class on a daily basis?

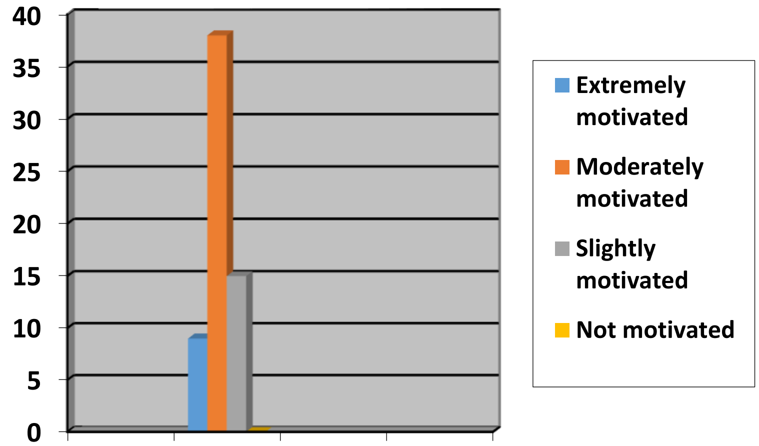


	Numbers	Percentage
Extremely prepared	4	6.45%
Moderately prepared	45	72.58%
Slightly prepared	12	19.35%
Not prepared	1	1.61%

Q5. What is the level of engagement among your students?

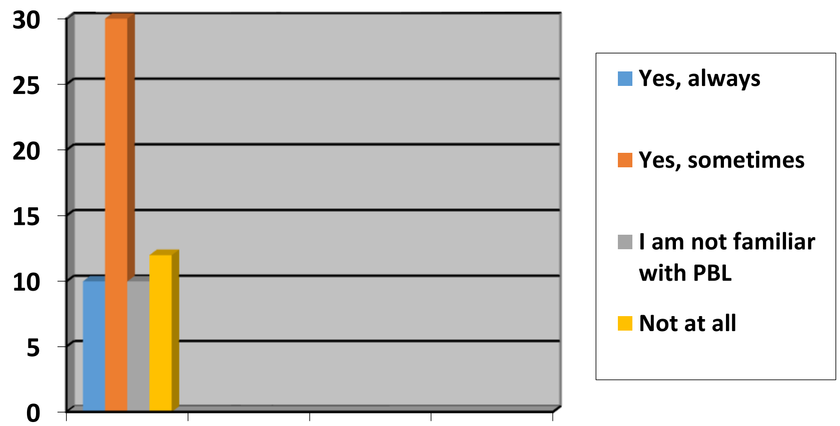
	Numbers	Percentage
Extremely engaged	13	21.67%
Moderately engaged	44	73.33%
Slightly engaged	3	5.00%
Not engaged	0	0.00%

Q6. How motivated are students in your classroom?



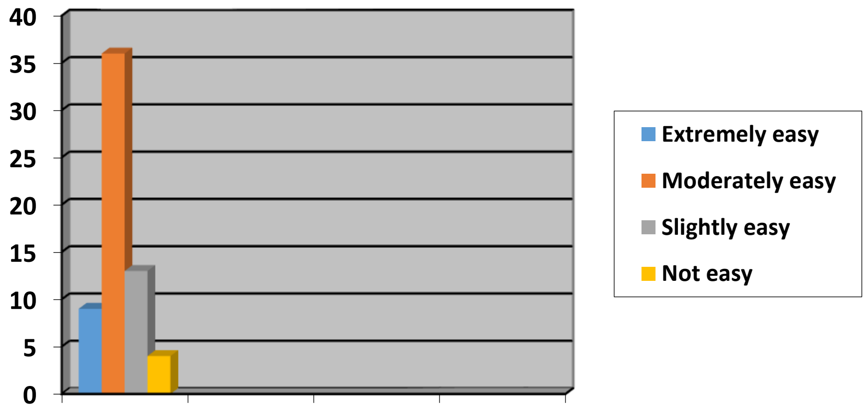
	Numbers	Percentage
Extremely motivated	9	14.52%
Moderately motivated	38	61.29%
Slightly motivated	15	24.19%
Not motivated	0	0.00%

Q7. Do you use Problem Based Learning (PBL) in your classroom instruction?



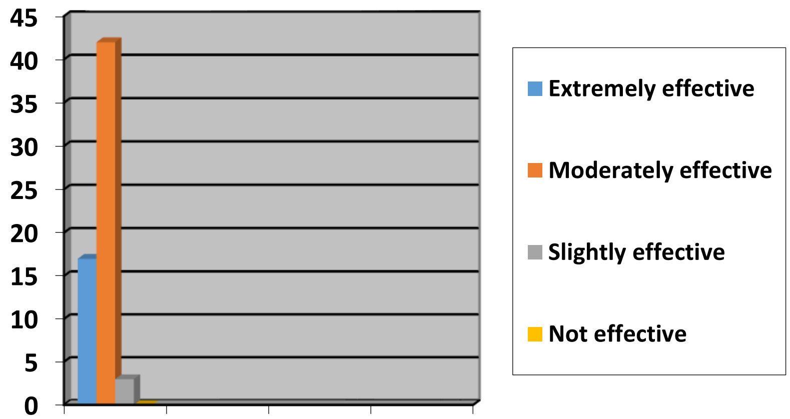
	Numbers	Percentage
Yes, always	10	16.13
Yes, sometimes	30	48.39
I am not familiar with PBL	10	16.13
Not at all	12	19.35

Q8. How easy is it to get resources you need to teach in your classroom?



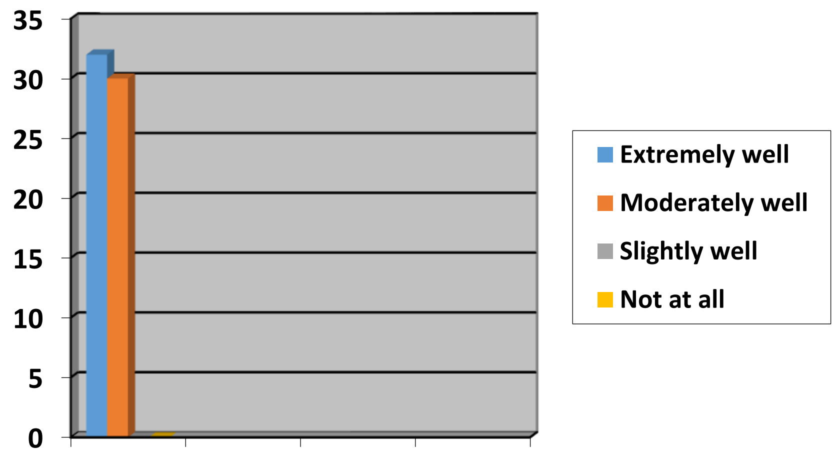
	Numbers	Percentage
Extremely easy	9	14.52
Moderately easy	36	58.06
Slightly easy	13	20.97
Not easy	4	6.45

Q9. How effective are instructional methods you use in your classroom?



	Numbers	Percentage
Extremely effective	17	27.42%
Moderately effective	42	67.74%
Slightly effective	3	4.84%
Not effective	0	0.00%

Q10. How well do you consider the individual needs of students in your classroom?



	Numbers	Percentage
Extremely well	32	***51.61%***
Moderately well	30	48.39%
Slightly well	0	0.00%
Not at all	0	0.00%

Appendix K

NC Report Card 2015/2016

NC Report Card

Achievement Indicators	Score
English II Proficiency	59
Math I Proficiency	50
Biology Proficiency	56
The ACT Proficiency	55
ACT WorkKeys	79
4-Year Graduation Rate	93
Passing Math III	95
'.' = < 5% of students; 95% =≥ 95%	

Growth Status
Met

	Score	Grade
Achievement	67	
Growth	73.3	
School Performance	68	C
EOG Reading	.	
EOG Math	.	

Source: Department of Public Instruction Website

Appendix L

2015/16 NC Public Schools Graduation Report

2015/16 NC Public Schools Graduation Report

Subgroup	Denominator	Numerator	Percent
All Students	328	304	92.7
Male	180	163	90.6
Female	148	-	>95
American Indian	*	*	*
Asian	7	-	>95
Black	79	-	>95
Hispanic	55	44	80.0
Two or More Races	11	10	90.9
White	173	164	94.8
Economically Disadvantaged	147	134	91.2
Limited English Proficient	5	3	60.0
Students with Disabilities	26	20	76.9
Academically Gifted	48	-	>95

Source: Department of Public Instruction Website

Appendix M

STEM Pathway

STEM Pathway

Typical	Rigorous	Advanced	Most Advanced
STEM Hon. English 1	STEM Hon. English 1	STEM Hon. English 1	STEM Hon. English 1
STEM Hon. World Hist.	STEM Hon. World Hist.	STEM Hon. World Hist.	STEM Hon. World Hist.
STEM Hon. Physics	STEM Hon. Physics	STEM Hon. Physics	STEM Hon. Physics
STEM Hon. Math 2	STEM Hon. Math 2	STEM Hon. Math 3	STEM Hon. Math 3
Health/ PE	Health/ PE	Health/ PE	Health/ PE
Tech. Engineering & Design (YL)	Tech. Engineering & Design (YL)	Tech. Engineering & Design (YL)	Tech. Engineering & Design (YL)
Design & Discover (YL)	Design & Discover (YL)	Design & Discover (YL)	Design & Discover (YL)
1 elective	1 elective	1 elective	1 elective
STEM Hon. English 2	STEM Hon. English 2	STEM Hon. English 2	STEM Hon. English 2
STEM Hon. Civics	STEM Hon. Civics	STEM Hon. Civics	STEM Hon. Civics
STEM Hon Biology	STEM Hon Biology	STEM Hon Biology	STEM Hon Biology
STEM Hon Math 3	STEM Hon Math 3	STEM Hon. Pre-Calculus	STEM Hon. Pre-Calculus
Technological Design	Technological Design	Technological Design	Technological Design
3 electives	3 electives	3 electives	3 electives
STEM Hon. English 3	STEM Hon. English 3	AP English Language	AP English Language
STEM Hon, American Hist. 1	STEM Hon, American Hist. 1	AP US History	AP US History
STEM Hon. Chemistry	STEM Hon. Chemistry	STEM Hon. Chemistry	STEM Hon. Chemistry
STEM Hon. Discrete Math	STEM Hon. Pre-Calculus	AP Calculus AB	AP Calculus AB
Engineering Design (optional)	Engineering Design (optional)	Engineering Design (optional)	Engineering Design (optional)
3 electives	3 electives	3 electives	3 electives
STEM Hon. American History 2	STEM Hon. American History 2	AP European History/social studies elective	AP European History/social studies elective
AP Chem./ AP Bio/ Science elective (recommended)	AP Chem./ AP Bio/ Science elective (recommended)	AP Chem./ AP Bio/ Science elective (recommended)	AP Chem./ AP Bio/ Science elective (recommended)
STEM Hon. Pre-Calc. or AP Stats	AP Calculus AB or AP Stats.	AP Calc. BC or AP Stats.	AP Calc. BC or AP Stats.
Cluster completer course	Cluster completer course	Cluster completer course	Cluster completer course
3 electives	3 electives	3 electives	3 electives